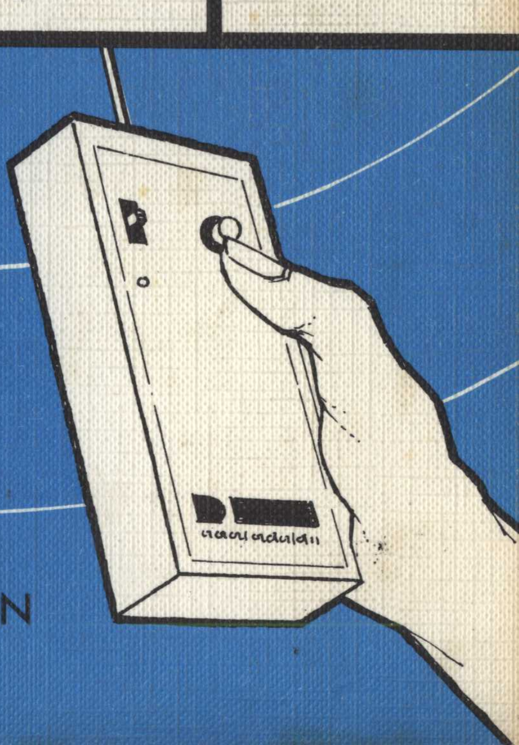
simple single channel RADIO CONTROL

R. H. Warring



MAP TECHNICAL PUBLICATION

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R. H. WARRING

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INTRODUCTION

Modern radio control equipment is generally so reliable that it can be regarded as 'black boxes'. This implies that they are working electronic units which merely need switching on to operate. The user of radio control equipment takes their performance for granted. In the event of a failure, which is normally due to crash damage rather than a failure of the electronic side, the unit must be returned to the manufacturer or his service agent for checking and repair as necessary. Very few modellers have the technical competence or even the interest to attempt to evaluate and trace faults in electronic circuits.

The operation of radio control equipment is further simplified by the fact that many combinations are supplied in 'plug-together' designs; this means that the receiver is pre-wired to a plug, the actuator or actuators also pre-wired to plugs, and a wiring harness or battery connection is included in the complete outfit. No wiring-up is necessary other than simply plugging the respective plugs into the correct sockets. Not only does this mean that mistakes in connection are absolutely impossible, but soldered joints or other types of connections which have to be made by the user are eliminated.

Most modern transmitter and receiver combinations are also factory pre-tuned. Such a TX/RX set is commonly called a combination or 'combo'. Reliability in operation should be as good as any domestic radio. Unlike a domestic radio, of course, model radio control equipment can be subject to abuse. A jolt or a crash landing can damage the receiver or actuator, excessive engine vibration can upset installation and perhaps break a lead, although if this occurs it is usually the fault of the installation. Transmitters are quite robust units but obviously they can be damaged if they are dropped. Electronic black boxes must, in fact, be treated as exactly what they are – electronic units – and kept dry, avoiding rough handling, and operated properly according to manufacturers' instructions.

All this is a far cry from the early years of radio control when transmitters and receivers were often home-built, there being very few commercial sets available. Even the actuators had to be home-made, using electric motors as a base or even starting from first principles and making escapement type units. The reliability in those days was poor, giving radio control, and single-channel control in particular, a bad name. This now no longer applies. The only limitation with single-channel control radio is, in fact, the scope of

control offered. Single-channel means a single signal, therefore only one signal can be given at a time as a command. Any response at the receiver end to such single signals, therefore, must occur in sequence. This is a basic limitation of all single-channel control systems. However, the advantages of a lower cost for single-channel, low installation weight and overall simplicity, makes it one of the most popular forms of radio control, in this country at least. Despite the limitations of single-signal control, much can be done in the way of selecting particular movements required and also operating additional controls via suitable sequences or sequence switching.

One of the advantages of modern radio control equipment is that it is all transistorised and the valves are eliminated entirely both in the transmitter and receiver. Apart from savings in bulk and weight (and the utilisation of solid state circuits which are less susceptible to accidental damage than valve circuits), another great gain is in the battery size and power required. Only small, low voltage batteries are needed both to operate the receiver and the transmitter. A single battery in the case of the receiver can also provide power for the actuator.

This book presents single-channel radio control installation, operation, etc., in a straightforward, practical manner. It assumes no knowledge of electronics, nor is electronics dealt with as a subject. It is the control function and control application that is important to the average user, or shall we say the majority of radio control enthusiasts.

Single-channel controls can be applied to aircraft, cars, boats, and a variety of other applications. Model aircraft are a primary interest, because remote control offers so much more interest and scope. An aircraft has to be controlled in three dimensions, and considerable piloting skill is needed to achieve aerobatic performance. Design of the model is also important in single-channel aircraft.

Boats offer considerable scope for sequential control operation because none of the controls is critical as in the case of aircraft. In other words, although rudder is a main functional control on boats, loss of rudder control or non-operation of rudder control does not necessarily put the boat in hazard. In the case of an aircraft, clumsy use of rudder control, or pilot error, is the most common cause of crashes.

The application of single-channel radio control can also be extended to proportional systems, known as pulse proportional. These are not true proportional systems but can give the same type of movement as more elaborate radio control systems, at a fraction of the cost.

The electronics are more complicated, but here again where these systems are described it is the function only we are concerned with, how they can be used and applied. Each chapter is complete in that it deals with one particular aspect of radio control installation and operation. It can be studied separately or used as a source of reference, as necessary.

The appendix data summarises the equipment available which can be studied in conjunction with the recommendations for types of controls, etc.

Finally, it should be mentioned that although model radio control

operates on a relatively unrestricted basis, transmission is limited to a specific frequency band, known as the 27 megacycle band. Also, to operate radio control equipment a licence is needed. This does not involve passing an examination or any practical test, but is merely granted on application and payment of the appropriate fee. Application involves merely completion of an application form, which can be obtained from:

The Ministry of Posts and Telecommunications,
Waterloo Bridge House,
Waterloo Road,
London, S.E.1.

The technical requirement, i.e. operating on the 27 megacycle band, is covered by the design of the 'black boxes'. The licence side is one which every modeller must take on himself. Operation without a licence can, under certain circumstances, lead to prosecution and also give the radio control model movement a bad name. The cost of a licence is £1·50 and since it is valid for a period of five years, this represents a cost of only 30p per year.

CHAPTER ONE

SINGLE-CHANNEL BLACK BOXES

The transmitter and receiver are the basic units in a radio control link. The transmitter is a signal generator, the signal being radiated from the aerial at a specific radio frequency (RF). In the case of model radio control transmitters this is a frequency in the 27 megacycle (27 Hz) band. The receiver is tuned to this frequency just as a domestic radio is tuned to a particular broadcast frequency. The main difference is in the simplicity of signalling. The signal sent by the transmitter can be in the form of a continuous carrier wave (CW) which is a simple signal sent at a radio frequency. Alternatively, the transmitter carrier wave can have a 'tone' or audio frequency (AF) signal superimposed on it.

In either case the end result is the same as far as the receiver is concerned. It reacts to reception of the particular signal to which it is tuned. Command is provided by switching the transmitter signal on and off. Transmitter signal 'off' corresponds to one state of the receiver; transmitter signal 'on' corresponds to a change in state of the receiver. In a complete radio control system, this change in state of the receiver works in the manner of a switch.

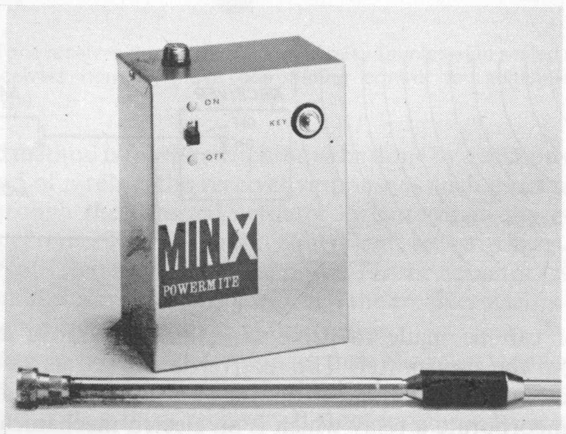


Plate 1 Typical single-channel transmitters controls are an on-off switch and separate microswitch 'keying' button

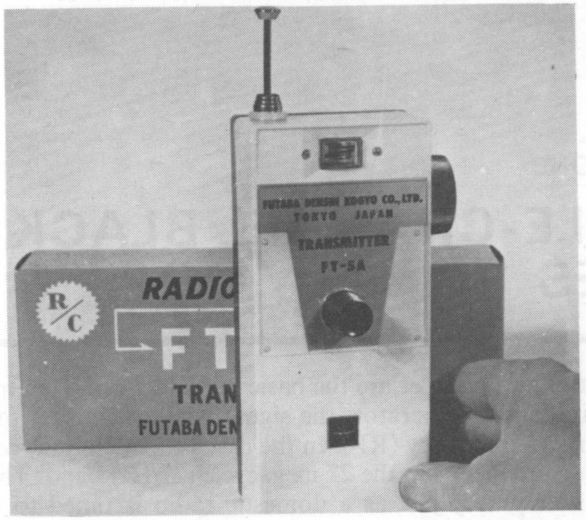


Plate 2 The Japanese have been prolific manufacturers of single-channel equipment, with a wide diversity of transmitter types

To complete the radio control system the receiver is coupled to an actuator, which is a device for providing the muscle power or mechanical output corresponding to the command signal.

The simplest way to understand this is to consider the case of a very basic type of actuator, i.e. an electric motor. The receiver acts as a switch for the actuator (electric motor). Thus in response to a command signal from the transmitter, the receiver either switches the motor circuit 'on' or 'off'. (Fig. 1.1).

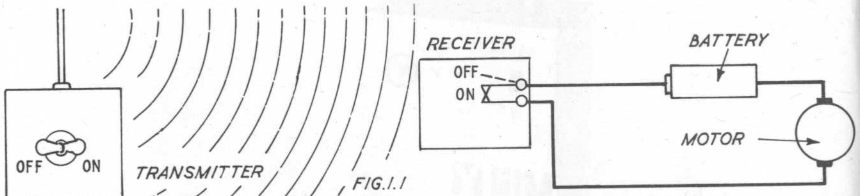


FIG. 1.1

This motor can be made to drive something, or move a control, on command from the transmitter. The receiver is worked as a switch for the actuator (electric motor) circuit in one of two ways. In the first case, the receiver can incorporate a relay which is an electro-mechanical switch. The change of state of the receiver responding to the transmitter command signals causes the relay to pull in or drop out thus opening or closing the relay

contacts. These relay contacts are connected directly to the external actuator circuit and thus work purely as an on-off switch for that circuit – Fig. 1.2. This type of receiver is known as a *relay receiver*.

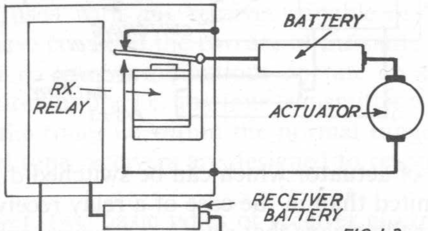


FIG. 1.2

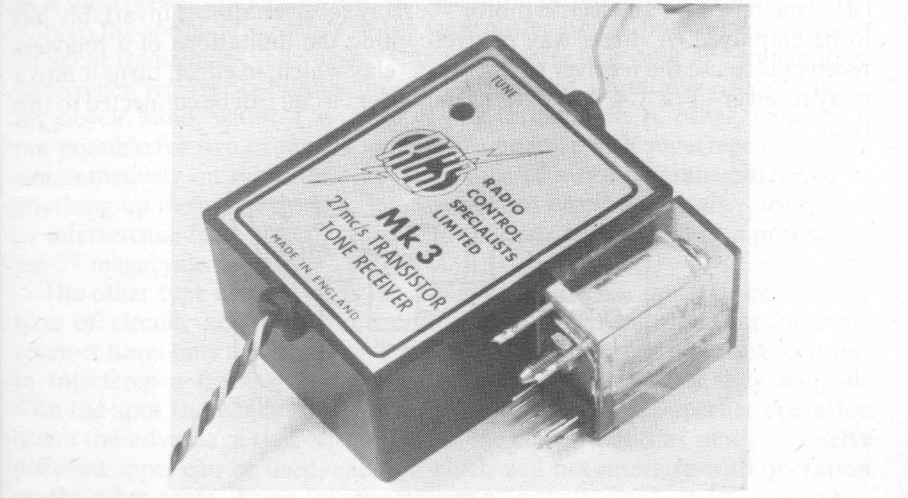


Plate 3 Tone receiver shown with separate relay (enclosed in sealed transparent case). Receivers normally have one tuning control for adjustment, unless superhet type

The second method is for the switching to be done by a section of the receiver circuit. Instead of a relay, the receiver response is such as to provide a flow of current through the external actuator circuit; or in the other state, to provide no current. This is again equivalent to switching the actuator circuit 'on' or 'off', but in this case the power for the actuator (electric motor) is derived from the current flowing through the receiver itself – Fig. 1.3. This type of receiver is known as a *relayless receiver*.

The relayless receiver is more compact than the relay receiver because the relay itself is eliminated, as is also the battery required in the external actuator circuit with a relay receiver. It does have one basic disadvantage, however. The switching of the actuator current is done through transistors and the current which this type of switching circuit can provide is relatively

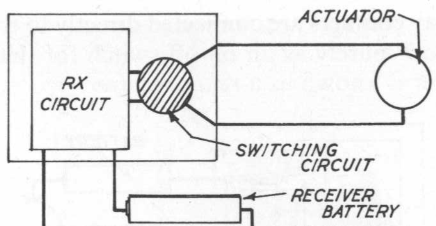


FIG.1.3

low. Thus the type of actuator which can be switched directly by a relayless receiver is more limited than in the case of a relay receiver.

In practice, this really means that *relayless receivers* are generally best used with *escapement type* actuators. For operation of a motorised actuator, i.e. – one based on an electric motor – a relay receiver almost invariably has to be employed. A direct way of overcoming the limitations of a relayless receiver is to use the receiver to operate a relay which, in effect, turns it into a relay receiver – Fig. 1.4. Any external actuator circuit can be connected to this relay.

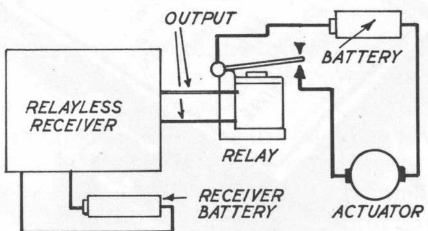


FIG.1.4

Most modern receivers are, in fact, virtually identical as regards circuitry, whether of relay or relayless type. Thus a particular receiver may be available in either relay or relayless versions.

A specific requirement in the case of a relayless receiver is that the actuator load be matched to the output of the receiver. This normally means an escapement type actuator with a coil resistance of about 8 ohms; or in the case of an added-on relay, known as a slave relay, a coil resistance of about 30 ohms.

No such limitation applies in the case of a relay receiver. The relay contacts form part of a separate circuit to the radio side, and work as an on-off switch for that circuit. Thus the type of actuator included in this circuit is not significant. It can be an escapement, or a motorised actuator, with the separate battery in the actuator circuit selected to suit. The only limit on current in this circuit is the current rating of the *relay contacts,* which are usually high enough to accommodate the demands of any conventional type of motorised actuator or small electric motor.

Returning to the transmitter, the RF signal generated is normally (but not invariably) crystal controlled. This means that the radio frequency signal is sent out at a specific 'spot' frequency. It is thus only necessary that the receiver be capable of being tuned to a particular frequency. Virtually *any* transmitter can be used with *any* receiver capable of being tuned to the transmitter frequency; provided the two are of the same *type*. Practically all modern transmitter/receiver combinations operate on a tone signal, when the same considerations apply, i.e. any tone transmitter will operate any tone receiver, provided the tones lie within the normal range of 600–1,000 Hz. Most single-channel tone receivers are designed to respond to this order of tone frequency.

There are, however, two basic types of receiver electronic circuits, quite apart from relay or relayless versions. The simplest type of circuit is known as a *superregenerative receiver*. This has quite broad tuning. It will tune not only to the specific frequency of the transmitter signal, but will accept other adjacent frequencies. The disadvantage of this is that only one transmitter/superregen receiver combination can be operated simultaneously on the 27 megacycle band, within the range of any transmitter. In other words, it is not possible for two or more modellers to operate with superregen receivers simultaneously on the same site. The range of a typical transmitter can be anything up to two or three miles. Superregen receivers are also susceptible to interference from other spurious broadcasts which might be present on the 27 megacycle band.

The other type of receiver is the *superhet*, which is a much more selective type of circuit, and also more complicated electronically. The superhet receiver tunes only to a single or 'spot' frequency. It is thus far less susceptible to interference from spurious transmissions, except when they coincide with the spot frequency to which the receiver is set up. Superhet operation offers the advantage that within the 27 megacycle band as many as twelve different spots can be used, each of which will not interfere with operation on the other spots. These frequencies are:

26·975 Hz	designated by flag colour	grey/brown
26·995 Hz	,, ,, ,, ,,	brown
27·025 Hz	,, ,, ,, ,,	brown/red
27·045 Hz	,, ,, ,, ,,	red
27·075 Hz	,, ,, ,, ,,	red/orange
27·095 Hz	,, ,, ,, ,,	orange
27·125 Hz	,, ,, ,, ,,	orange/yellow
27·145 Hz	,, ,, ,, ,,	yellow
27·175 Hz	,, ,, ,, ,,	yellow/green
27·195 Hz	,, ,, ,, ,,	green
27·225 Hz	,, ,, ,, ,,	green/blue
27·255 Hz	,, ,, ,, ,,	blue

The usual number of operating spots is restricted to six as indicated in bold type. This means that up to six different superhet receiver/transmitter combinations can be operated simultaneously from the same site.

The superhet receiver has some disadvantages, the main one being that it is more costly than a superregen receiver. It is also more difficult to tune and align. Thus while superregenerative receivers are usually fitted with tuning adjustment and can, if necessary, be tuned to match any transmitter, the superhet receiver is tuned to a specific transmitter – i.e. to a specific spot frequency. The transmitter/receiver combination is matched by a pair of crystals, one in the transmitter controlling the transmitter frequency, and one in the receiver. The combination is usually factory pre-set and the superhet receiver should not be re-tuned by an inexperienced operator.

The setting up of a superhet receiver also involves alignment of the various stages – this is also pre-set at the factory and should not be further tampered with in use. For superhet operation one purchases a matched transmitter/receiver combo. The same transmitter can be used to operate further receivers, provided these are fitted with matching crystals, tuned to the spot frequency. In other words, one transmitter can operate receivers in several different models if required. Also it is possible to change the operation from one spot frequency to another by changing the pair of crystals, i.e. the transmitter crystal and the matching receiver crystal. Thus superhet equipment crystals are normally bought in *matching pairs*.

One technical point needs explaining here. Although the transmitter (Tx) and receiver (Rx) crystals for superhet operation are a matched pair, they are not identical in actual calibrated frequency. This is because a superhet receiver operates on a slightly different frequency to that of the signal being received. The difference in frequency, known as the intermediate frequency (IF) can be above or below the transmitter frequency, but in conventional practice is below the transmitter frequency. This means that an Rx crystal has a slightly lower actual (calibrated) frequency than a matching transmitter crystal.

Crystal pairs are normally clearly marked Tx and Rx (or otherwise readily identified), so there should be no problems in which plugs into which unit. If a second superhet receiver is bought to work with the same transmitter, however, this must be fitted with a suitable *Rx crystal* to match the original transmitter frequency.

'Carrier' versus 'Tone' operation

The slightly more complicated tone operation is more effective than carrier operation. This is because the true RF radio frequency signal is always present with a tone transmitter/receiver link and the receiver tends to 'lock on' to the signal. It is thus more responsive to the tone signal when present, and less susceptible to interference from other signals. It is not free from interference, however, unless the receiver is a superhet type.

A few carrier type transmitters may still be in use and these can only be used with carrier type receivers. The only advantage offered by a carrier transmitter/receiver combination is that the circuits are a little more simple and thus less expensive to produce. Some kits for making transmitters and matching receivers are of this type. For all general use a tone transmitter and tone receiver combination is to be preferred.

The main points to appreciate, when selecting equipment, are:

(i) A 'carrier' (CW) transmitter will only work a 'carrier' (CW) receiver.

(ii) A 'tone' transmitter will work with most types of 'tone' receivers (as previously noted). The transmitter and receiver do not necessarily have to be of the same make, although it is more usual to select transmitter-receiver combinations of the same make.

(iii) A 'tone' transmitter can also work a 'carrier' receiver, but will (usually) require a modification of the circuit to do so. This is because a 'tone' transmitter sends out a continuous CW signal once it is switched on, and only the 'tone' is keyed for signalling. Thus the circuit must be modified so that the keying switch breaks the 'carrier' signal as well to operate a 'carrier' receiver.

One interesting point arises here. If a 'tone' transmitter is modified in this way to operate a 'carrier' receiver, it will still also operate a 'tone' receiver in this condition (keying both 'carrier' and 'tone' on and off simultaneously). However, the advantage of having a continuous carrier will be lost.

Other Selection Pointers

All modern radio control equipment is invariably transistorised. The size of equipment can vary considerably, transmitters are normally designed to be hand held, and can range in size from very small, almost pocket-sized units, up to fairly large (but still not too heavy) boxes.

The miniature size transmitters obviously have attractions, but as a general rule, the larger the physical size of the transmitter the more power and range it is likely to have. It is also generally more reliable because larger batteries can be used, although it is the power input to the transmitter which really governs the amount of radiated output power. The actual power output is determined by the efficiency of the transmitter circuit. A transmitter as such has no particular range; range can only be quoted in terms of a particular transmitter/receiver combination. A transmitter used with one receiver may give a range of say one mile and with another receiver perhaps half this range, both receivers being adjusted to optimum tuning. It is a matter of receiver sensitivity and circuit efficiency.

Maximum range is required when operating a radio controlled model aircraft. Here a ground-to-ground range of about 400 yards is generally quite adequate. When the model is airborne this range will, in fact, be increased by some two or three times. At this distance it is impossible to tell in which direction the model is flying and so this represents the maximum practical range. For model boats and model cars, of course, a much shorter range is required.

Plate 4 Single-channel transmitters can be made very small and compact, but with small battery are limited in power and range. *Right* Battery (9 volt PP6)

Excessive range is not desirable in any case with model radio transmitters, as this can then interfere with other receivers at a distance and beyond the usable range of the unit. Excessive range will only be obtained at the expense of excessive input power, which means higher battery drains and higher operating costs. It would not necessarily increase the efficiency of operation over a shorter range. Any modern transmitter/receiver combination of the same make, should give adequate range for all types of model operation. The same may not apply to a transmitter of one make and a receiver of another make. However, this may be checked by a ground range test, e.g. if the transmitter/receiver combination proves responsible at a ground range of up to 400 yards, it should certainly be suitable for use in aircraft. Choice would then be based on other features of the transmitter.

The overall efficiency of a transmitter depends to a large extent on the efficiency of its aerial and matching circuit. A telescopic aerial is (almost) invariably fitted, intended to be fully extended for use. The aerial may incorporate a *centre loading coil* – identified physically as a bulged section in the middle of the aerial when in its extended position. This is to 'tune' the aerial for maximum efficiency (the loading coil is a fixed value and cannot be adjusted). It does not necessarily follow that a transmitter with a centre loading coil in the aerial is more efficient than one without. A similar type of

loading coil is incorporated in transmitters with plain aerials, connected to the base of the aerial and hidden inside the transmitter case.

For accurate command signalling a particularly good on-off switch is required on the transmitter. The best type of switch is a microswitch, which has a press button type of movement, and is very sensitive and responsive. Switching the command signal on or off, keying as it is generally known, cannot be done very effectively with a slide or toggle switch. The two latter types of switches are suitable only for on-off battery switches for the transmitter circuit. Other transmitters may have additional refinements such as separate push button switch for 'quick-blip' signalling, which is explained in Chapter 2. More elaborate transmitters may also have modified controls for commanding pulse proportional systems – see Chapter 9.

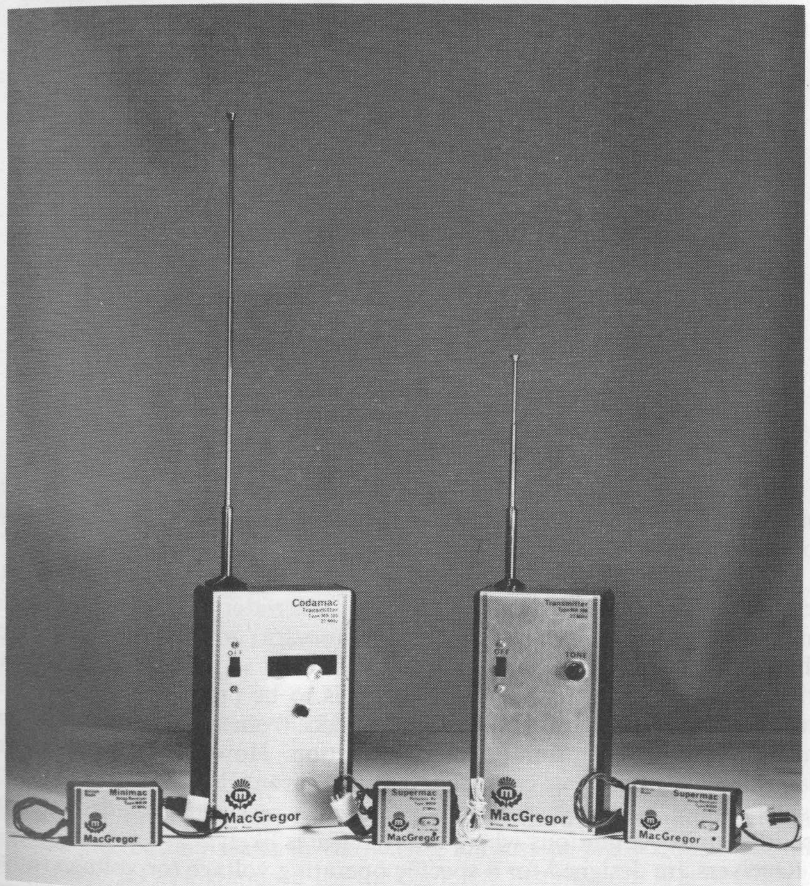


Plate 5 Modern British single-channel radio control transmitters and receivers. Transmitter on left is for single-channel proportional with joystick control replacing pushbutton. Separate button below is for additional control service

Most modern transmitter circuit designs are similar, and there is probably little to choose between them in the matter of efficiency. Some are designed to operate with dry batteries, the size of the transmitter case being proportioned to accommodate a particular size of battery. Others are designed to operate off nickel-cadmium batteries (DEAC) or perhaps take DEAC's or dry batteries as alternatives.

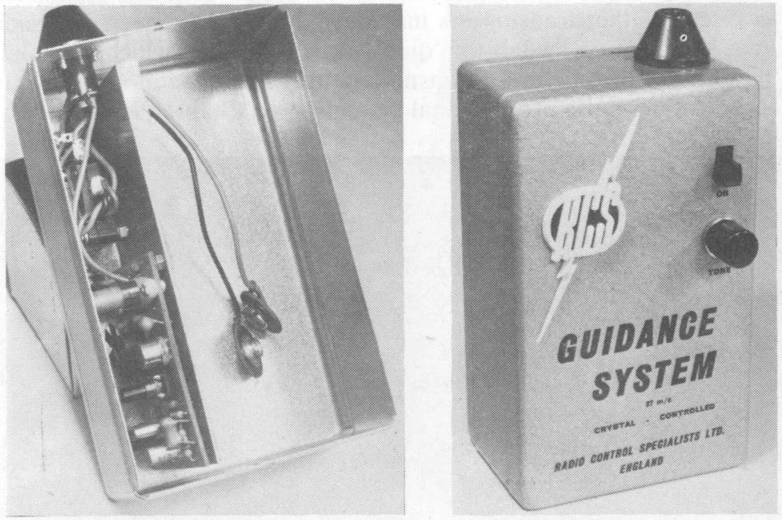


Plate 6 Transmitter cases are designed to accommodate a specific size of battery – usually a type fitted with press-stud connections

The preference is for nickel-cadmium batteries rather than dry batteries for transmitter power, since these are more stable and have a constant voltage output regardless of load. See Chapter 10.

Modern receiver circuits are also invariably all-transistor. Here detail design can differ more than in the case of transmitters. As a rough rule one can say that the greater the number of transistors in the circuit, the more efficient the receiver is likely to be. This, of course, will also increase the price of the receiver. A superhet receiver is to be preferred because of its greater selectivity, i.e. resistance to interference from spurious transmissions and its capability for simultaneous operation. However, the higher cost may rule this out in some cases. There is no reason why entirely satisfactory results cannot be obtained from a superregen receiver, provided it is not operated under conditions where interference is likely.

Receivers are designed for a specific operating voltage (or voltage range), and the choice of dry batteries or nickel-cadmium batteries is more open, unless governed by the form of plug-together wiring harness supplied as standard with the equipment. One manufacturer, for example, may include a

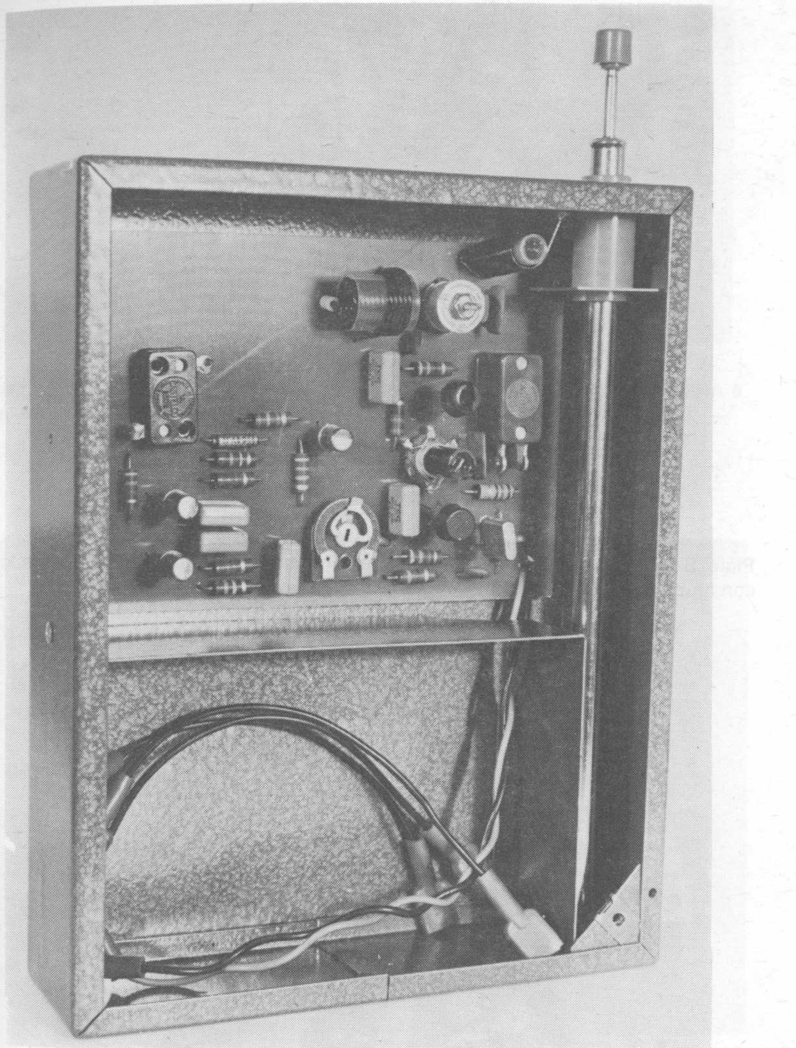


Plate 7 Rear view of another transmitter layout with battery space below circuit

battery box as standard in the receiver wiring harness, designed to take a standard size of dry battery (usually pencells). Another manufacturer may terminate the battery leads in the wiring harness in press studs matching DEAC batteries as a standard for the complete installation. It is possible to change from one battery type to another by altering the connections on prefabricated wiring harnesses, of course – but consult Chapter 10 for more information on batteries.

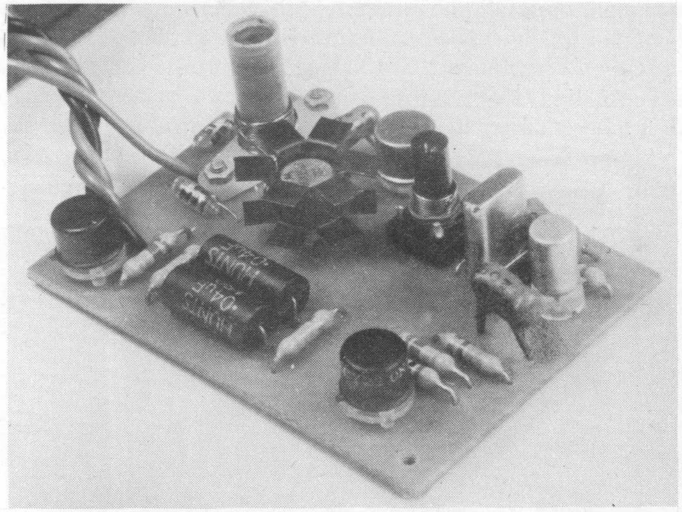


Plate 8 Home-built receiver circuits are commonly spread out for ease of construction

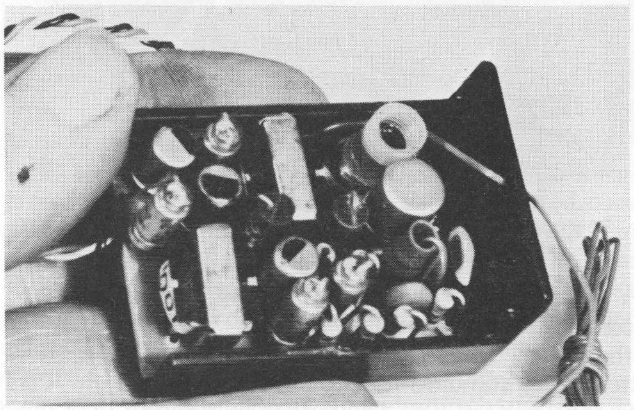


Plate 9 Commercial circuits are invariably compact and housed in metal or plastic cases

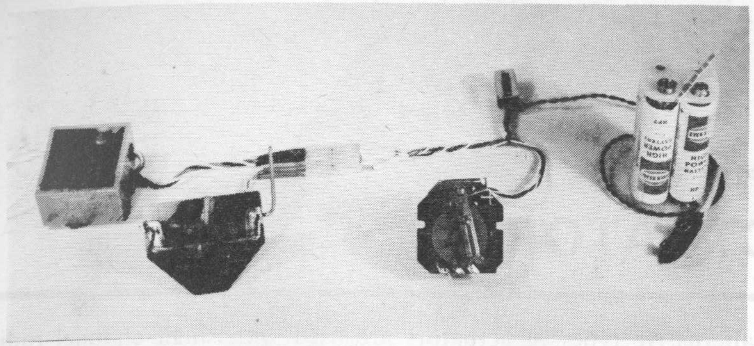


Plate 10 All modern commercial single-channel equipment is produced on a pre-wired plug-together basis to eliminate need for soldered connections

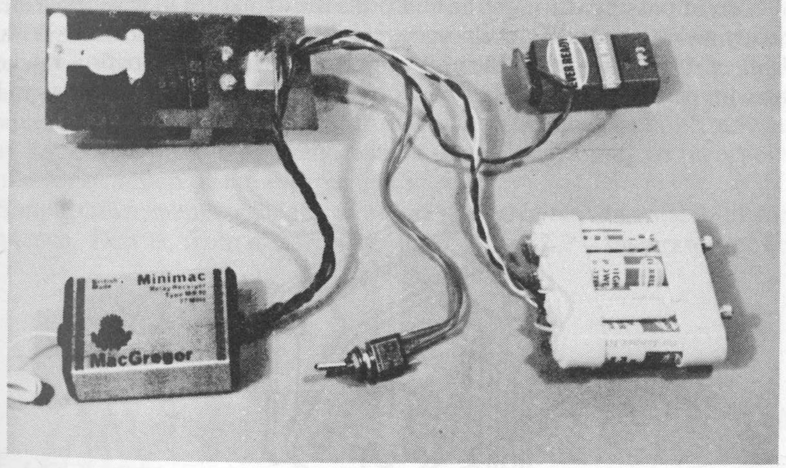


Plate 11 Another example of plug-together circuitry. The receiver harness also incorporates a prewired on-off switch

CHAPTER TWO

ACTUATORS

Two alternative types of actuators are used with single-channel radio – *escapements* and *motorised actuators* (also called single-channel servos), defined by their principle of operation. Actually there are other possibilities – magnetic actuators, solenoid-action actuators, etc., but these can be disregarded for general use. The functional control requirements of models can be provided by either an escapement or a motorised actuator, or combinations of these basic types.

An escapement can be thought of as a 'mechanical relay'. With an electrical relay, current passing through the coil pulls the armature in, this movement of the armature producing a changeover of the electrical contacts. With a *mechanical relay*, energising the coil to pull the armature in trips a ratchet-and-pawl type movement – Fig. 2.1. Some external form of power has to be

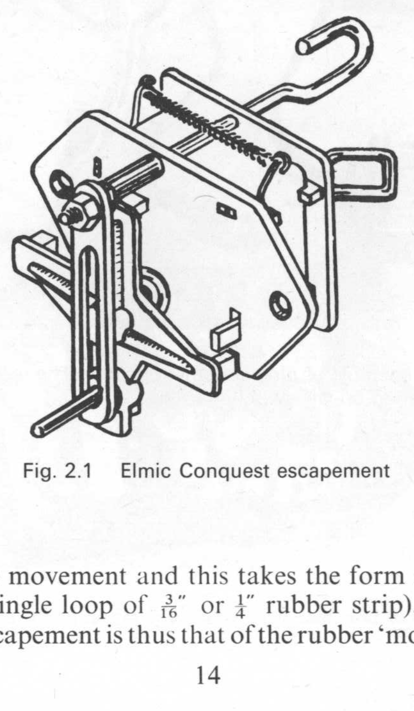


Fig. 2.1 Elmic Conquest escapement

applied to work the movement and this takes the form of a twisted rubber 'motor' (usually a single loop of $\frac{3}{16}''$ or $\frac{1}{4}''$ rubber strip). The output *power* available from an escapement is thus that of the rubber 'motor' used to drive it.

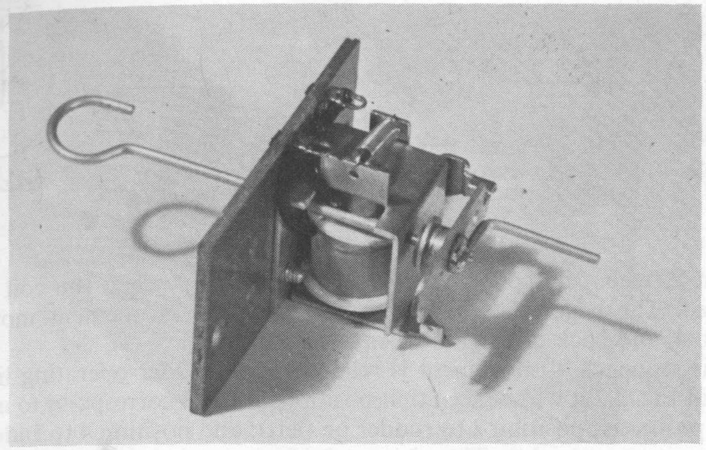


Plate 12 Mechanical output from an escapement is always in the form of a cranked arm. Loop at other end of spindle accommodates rubber strip drive

The output *movement* of an escapement is taken directly from the escapement arm (or disc) in the form of a crank motion. This can readily be turned into any other type of motion required by external linkage. Fig. 2.2, for example, shows how the basic 'crank' motion of an escapement can be coupled to a *yoke* and *torque rod* to operate a rudder. The yoke movement may have to be fitted separately, but on some designs may be incorporated in the construction of the escapement itself.

Simple escapements normally work on 90 degree movements, following in sequence. That is, from a starting point 1 – Fig. 2.2 – the crank moves to

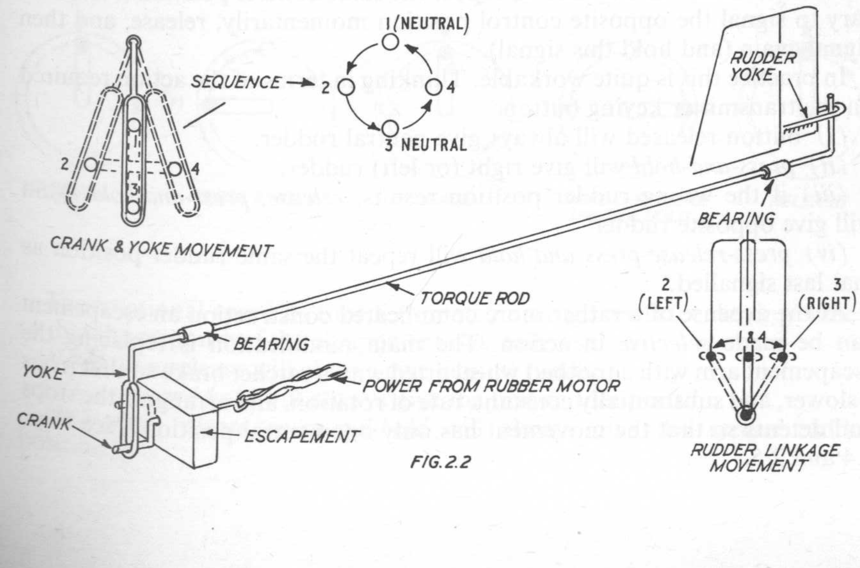


FIG. 2.2

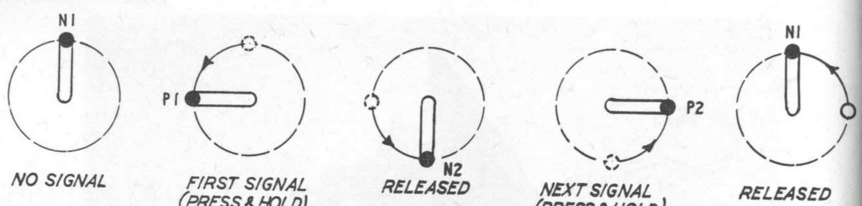


FIG. 2.3

position 2, when the coil is energised, then on to 3 when the coil is de-energised. The next time the coil is energised the escapement moves to position 4, and back to 1 again when de-energised.

If this sequence of movement is related to the rudder operating linkage shown in Fig. 2.2 it will be seen that positions 1 and 3 correspond to neutral rudder positions; position 2 to rudder on (left); and position 4 to rudder on the opposite way (right). Thus in terms of response to signal (signal 'on' corresponding to the escapement coil being energised):

No signal present gives neutral rudder (position 1).
Signal on gives left rudder (position 2).
Release of signal gives neutral rudder (position 3).
Signal on gives right rudder (position 4).

Giving a signal will thus alternately give left and right rudder, and to hold a rudder position the signal must be held on. Release of signal allows the movement to return to neutral rudder position. Thus the escapement is *self-neutralising* (S/N), with two control positions (2P). It also has two neutral positions (2N) – Fig. 2.3. This type of escapement would thus be described as *simple S/N 2P 2N*. (The 2N part is not important and can be ignored.)

The only real limitation with this type of movement is that it is necessary to remember which control position was signalled last to know what the next control position will be. Also to repeat the same control position it is necessary to signal the opposite control position momentarily, release, and then signal again (and hold this signal).

In practice this is quite workable. Thinking in terms of the action required on the transmitter keying button:

(i) button released will always give neutral rudder.
(ii) press-and-hold will give right (or left) rudder.
(iii) if the wrong rudder position results, *release, press-and-hold* again will give opposite rudder.
(iv) press-release-press and hold will repeat the same rudder position as that last signalled.

At the expense of a rather more complicated construction an escapement can be made *selective* in action. The main modification is replacing the escapement arm with a toothed wheel fitted with a ratchet brake so that it has a slower, and substantially constant, rate of rotation, and arranging the stops and detents so that the movement has only one neutral position – see Figs. 2.4 and 2.5.

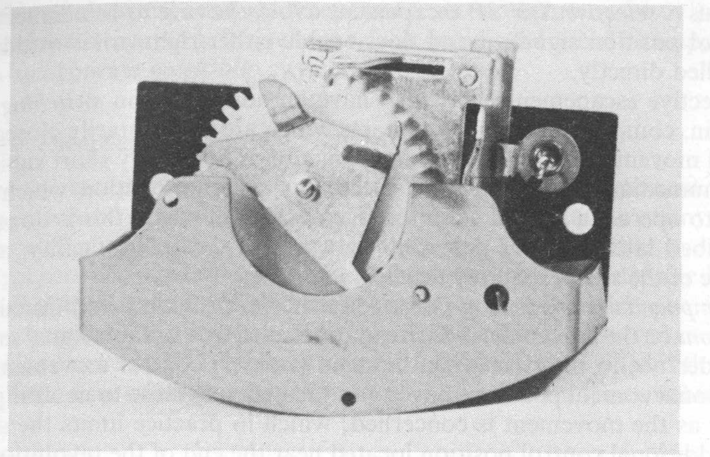


Plate 13 Selective type escapement invariably has rotational speed controlled by ratchet-type brake working on a large gear wheel

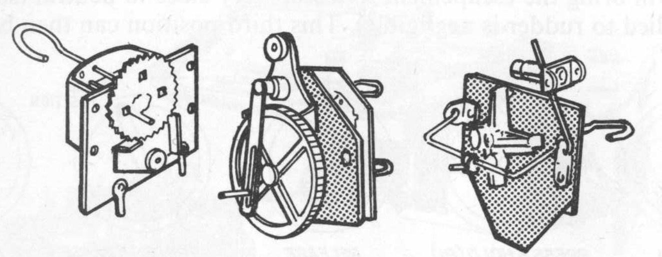


Fig. 2.4 Selective escapements (left), and modern control escapement (right)

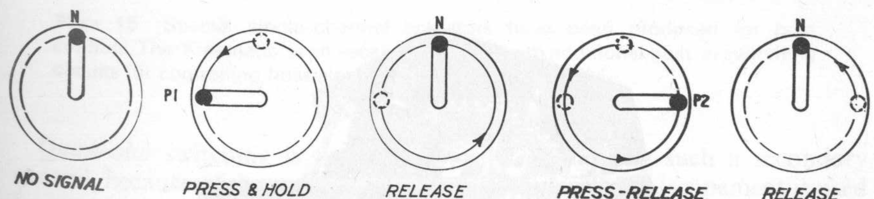


FIG. 2.5

The rotational speed is 'timed' to match average operator 'keying' times, so that the response of the escapement is as follows:

(i) button release will always give neutral rudder.
(ii) press-and-hold will always give the *first* rudder position.
(iii) press release press-and-hold will always give the *second* rudder position.

Thus a *selective S/N 2P* escapement avoids having to remember the last control position signalled and does enable either right or left rudder to be signalled directly.

Selective escapements may also have an additional on *switching facility* built in, comprising a pair of contacts which are momentarily closed by the initial movement away from neutral position. Thus a very short signal given and immediately released will 'select' this switching action which can be used to operate a second actuator (the manner in which this is done will be described later). This is generally known as a *quick-blip* facility, after the nature of the signal required to select it.

Compound escapements go a stage further in providing additional *control positions* on the movement, which can be selected by a suitable signal sequence. In order not to interfere with the main (rudder) control movements, such additional control positions have to be located very close to neutral position as far as the movement is concerned; which in practice limits the scope to one additional control position located near the end of the revolution of the wheel – Fig. 2.6. This would then be selected by the following signal: *press, release, press, release, press-and-hold.*

This will bring the escapement to a stop very close to neutral (so that the bias applied to rudder is negligible). This third position can then be used to

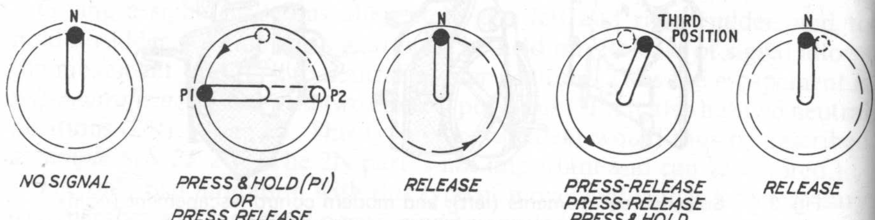


FIG. 2.6

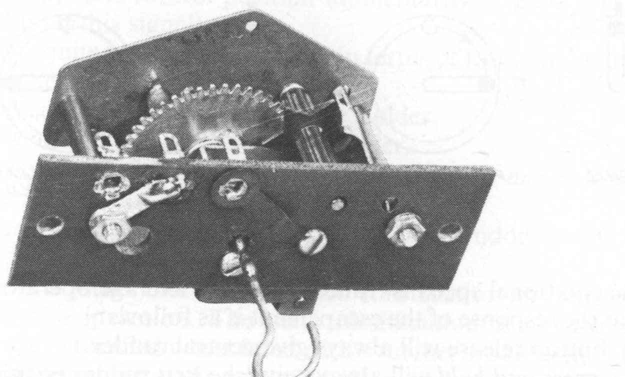


Plate 14 Compound escapement can provide selective control positions and additional switching facilities

close a pair of electrical contacts to operate a second actuator, or to work a mechanical movement (e.g. 'trip elevator'). A compound S/N 3P escapement can also incorporate *quick-blip* switching.

Secondary Escapements

A secondary escapement is one switched by the main escapement, thus providing a second control function. In theory, at least, it can be of any type, and also be used to switch a third escapement, and so on, further to extend the control services available. In practice, however, there are definite limits to *cascading* escapements in this manner, set by the fact that the signal sequences become too complicated to manipulate. This is covered in more detail in Chapters 3 and 7. The most usual second service provided is throttle control in the case of engine-driven models, or electric motor switching on boats, etc.

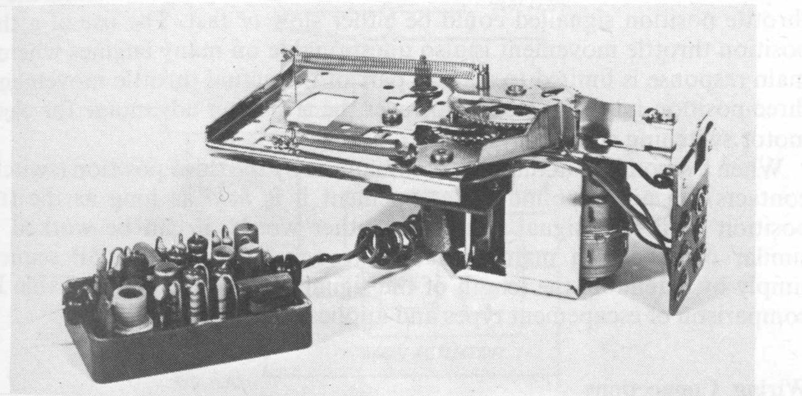


Plate 15 Special single-channel actuators have been produced for boat controls. The 'Kinematic' is an escapement type with additional built-in switching circuits for controlling boat electric drive motor

Quick-blip switching is to be preferred for selecting such a secondary control, because of the ease of signalling. If a S/N 2P 2N escapement is used for the secondary actuator, this will then have a changeover motion, since quick-blip contacts close only momentarily. The secondary escapement will move from 1 to 2 as soon as the quick-blip contacts on the main actuator close, then move on to 3 and stop immediately afterwards as the quick-blip contacts open again. In other words a 2P 2N escapement has to be used for the secondary actuator, with the output movement provided by the two neutral positions. This can provide throttle changeover from low to high, high to low, low to high, etc. – Fig. 2.7.

There is, however, the possibility of using a non self-neutralising or

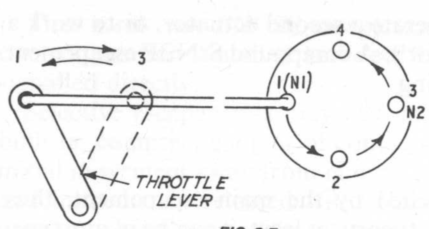


FIG. 2.7

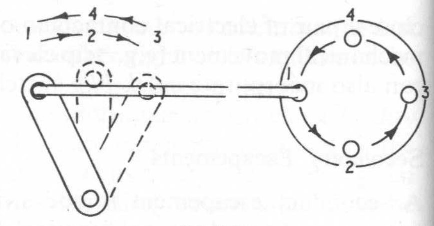


FIG. 2.8

progressive escapement for the secondary actuator. This is designed to be tripped by a signal, and on release of signal merely move a quarter-turn – Fig. 2.8. It will be seen that this type of escapement movement will give an intermediate throttle position, i.e. fast-intermediate-slow-intermediate-fast, etc., in sequence. This can have advantages on an engine fully responsible to throttle movement, although this may be offset by the less positive throttle position selection. For example, from an intermediate throttle setting the next throttle position signalled could be either slow *or* fast. The use of a three-position throttle movement is also questionable on many engines where the main response is limited to a small part of the actual throttle movement. A three-position movement can, however, be a distinct advantage for electric motor switching controls.

When a secondary actuator is commanded by the third position (switching contacts) on a compound 3P escapement it is *held* as long as the (third position sequence) signal is held. In other words, it can be worked in a similar manner to a main actuator through a 2P or even 3P sequence, simply by extending the length of the signal sequence. See also Table I for comparison of escapement types and applications.

Wiring Connections

In the absence of pre-wired plug-and-socket connections on commercial equipment, the following descriptions can be applied to sorting out the wiring connections for escapements.

In the case of a *relay receiver,* six wires normally emerge from the receiver case. One will be quite separate from the other (and commonly white in colour), and can be identified by its length (usually about 30 ins.) as the aerial. The other wires provide connections to the receiver battery and the relay contacts. Typical wiring connections to complete the circuit are then as shown in Fig. 2.9.

Relay connections are identified by the normally open (NO) and normally closed (NC) contacts, and the intermediate or common armature connection. Only the armature and NO connections are used to connect a main escapement, the NC connection being left unconnected to anything. A switch is necessary in the receiver battery circuit, but in theory at least is not necessary in the actuator battery circuit since the relay contacts are effective as a

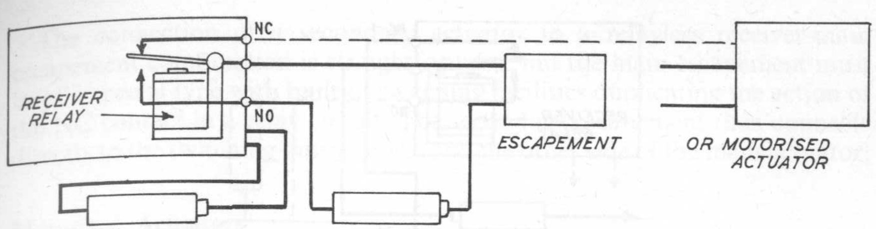


FIG. 2.9

switch for this circuit. However, many people prefer to include a switch in the actuator battery circuit as well. Thus a double-pole switch can be used and an on-off switch for batteries simultaneously.

The connections for a secondary escapement operated by a quick-blip switching facility on the main escapement are shown in Fig. 2.10. One lead

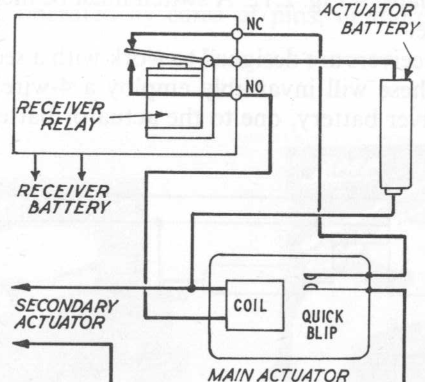


FIG. 2.10

from the secondary escapement is connected to one side of the same actuator battery, and the other side to one of the quick-blip switching contacts on the main actuator. The other side of the quick-blip switching contacts is then connected to the NC contact on the relay. This is necessary to ensure that the secondary actuator circuit is complete *only* in the presence of a quick-blip signal (sufficiently short to let the relay drop out before the contacts are closed). With any longer duration of signal (such as a normal 'selective' signal), the relay is still being held in as the quick-blip contacts are closed, leaving the secondary actuator circuit broken. If the NC contact of the relay is not used in this way the secondary escapement could be triggered by *every* signal given.

Similar considerations apply in the case of wiring a secondary actuator to a 3P switching position – although the actual connections are a little different – see Fig. 2.11.

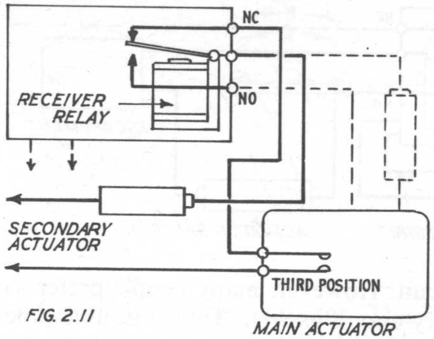


FIG. 2.11

Relayless receivers may have three or four wires emerging from the case (in addition to the aerial wire). In the case of a 4-wire system, two go to the battery and two to the actuator. With a 3-wire system, one is common to the battery and actuator – Fig. 2.12. A switch must be included in the battery circuit in either case.

Some relayless receivers are designed to work with a second battery for the actuator supply. These will invariably employ a 4-wire system, two going directly to the receiver battery, one to the actuator battery and the other to

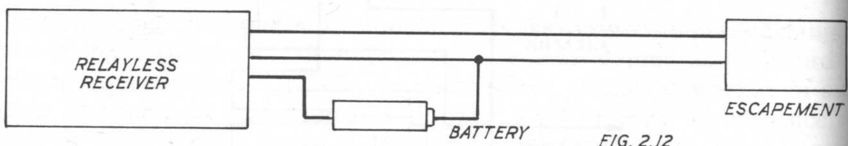


FIG. 2.12

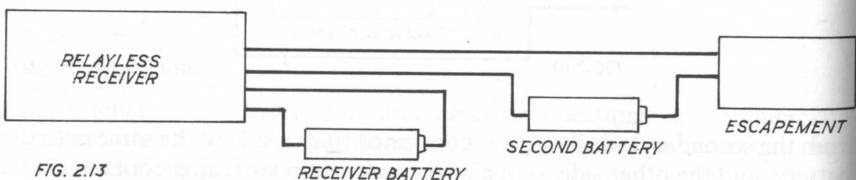


FIG. 2.13

the escapement – Fig. 2.13. On-off switching must be provided in both battery circuits. The advantage offered by a two-battery relayless system is that it puts the working on a similar basis to that of a relay receiver. That is, the receiver battery is relieved of actuator current demand; and the actuator battery size can be selected to suit the escapement used. The escapement coil resistance, however, must still be a suitable 'match' for the receiver.

Another variation on a similar theme is to use a single battery system with an amplifier built into the escapement circuit itself. Although this type of escapement is more expensive, it does relieve the receiver battery of a proportion of the load and boosts the operating voltage and current of the escapement to a reliable level.

The connection of a secondary actuator to a relayless receiver-main escapement combination is straightforward, but the main escapement must be of a special type with built-in switching facilities duplicating the action of the NC contact in a relay circuit. The secondary escapement then connects directly to the switching output point and the other side of the main actuator.

Motorised Actuators

These are based on small electric motors driving an output movement via suitable reduction gearing. Final output movement is again rotary, in a sequence of 90 degree steps, although the actual output movement is usually in the form of a disc with drilled linkage connecting point, a rocking tee-bar driven by a crank pin, or a rocking arm similarly driven – see Fig. 2.14. The latter type of output movement is normally only applied to progressive (3-position) secondary-type actuators.

Sequence movements – start and stop – are governed by switching contacts built into the unit, operated by cams or pins, or more usually in modern

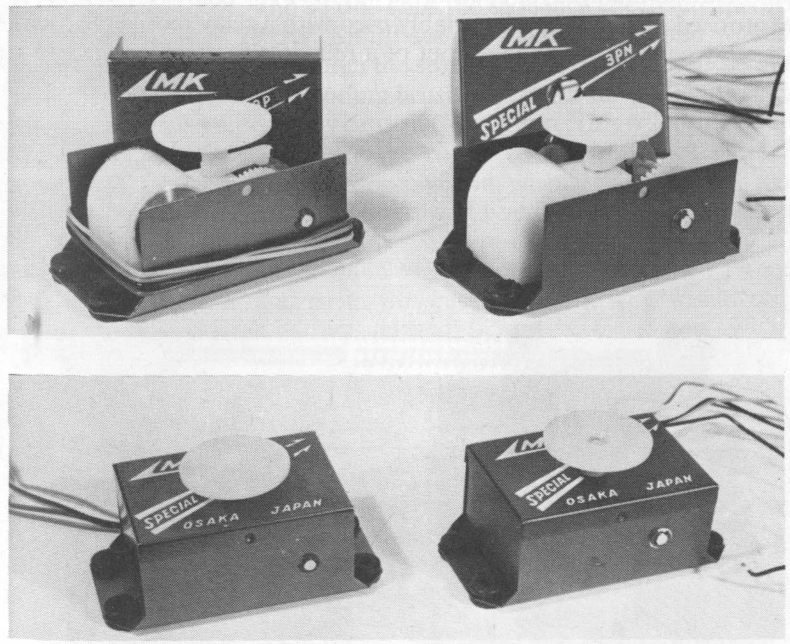


Plate 16 Motorised actuators are usually made in two basic types – one with selective action for rudder control (plus additional switching position); and the other with progressive action for throttle control

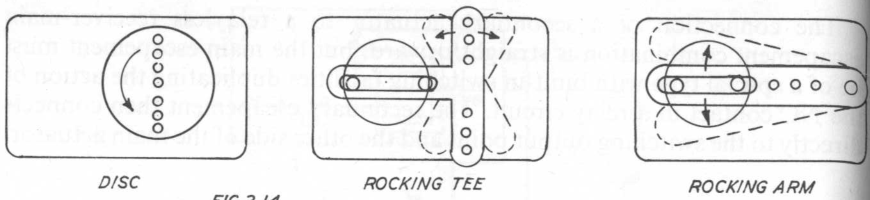


FIG. 2.14

motorised actuators by brushes sweeping over printed circuit switching panels. Similar types of movements can be provided as with escapements, e.g.

(i) S/N 2P, either simple or selective (the latter being usual).

(ii) S/N 3P selective, this can also incorporate quick-blip switching facilities.

(iii) progressive 2P.

(iv) progressive 3P.

These cover the main types, but there are numerous other possibilities for specialised applications. The combination of an electric motor with printed contact switching is a particularly flexible one, which can be further developed via mechanical linkages for specialised applications (e.g. see Chapter 7).

Motorised actuators are invariably used with a relay receiver, or switched via a relay connected to the output of a relayless receiver – Fig. 2.15 – and

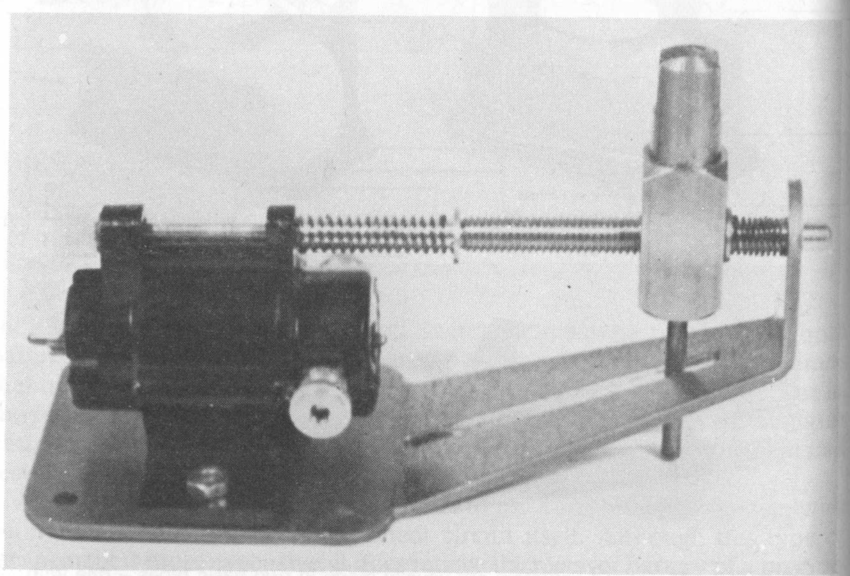


Plate 17 Adaption of an electric motor for linear motion 'progressive' output – e.g. for sail winching or similar duties (see also Chapter 7)

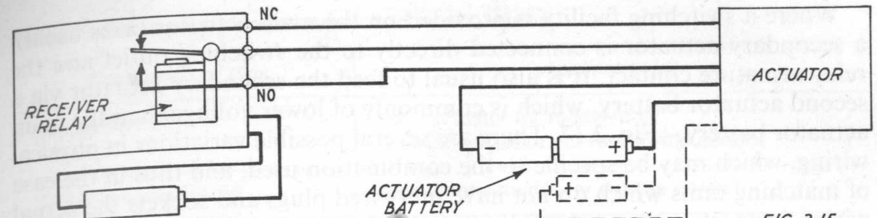


FIG. 2.15

powered by a separate actuator battery. This battery commonly comprises two sections for a main actuator – one for powering the servo and the other for ensuring positive positioning on stop. This is known as 'sniff-back' action.

All three relay contacts are used for switching and work in this manner. On receipt of signal the relay pulls in, changing over the armature to the NO contact. This completes the battery circuit for the motor to drive to its first sequence position, where it will stop under the built-in switching circuit. On release of signal the relay contacts change over, causing the motor to drive to the next sequence position, and again stop. In the case of a main actuator, alternate stop positions correspond to neutral, control position, neutral, control position, and so on. Thus the sequence effectively incorporates self-neutralising – 2P 2N. Sniff-back may be incorporated to ensure positive positioning. Thus although the stop positions will be predetermined by the points at which the controlling brush sweeps off the end of its contact strip, the inertia of the motor may cause it to over-run. This will bring another contact into operation completing the circuit to the sniff-back battery to drive the motor back to its proper stop position, when it will switch off again. It thus follows that the sniff-back battery will be connected the opposite way round in the circuit.

A typical wiring circuit is shown in Fig. 2.16. Not all motorised actuators have sniff-back circuits, and so in this case the extra wire would not be present (and the sniff-back battery omitted).

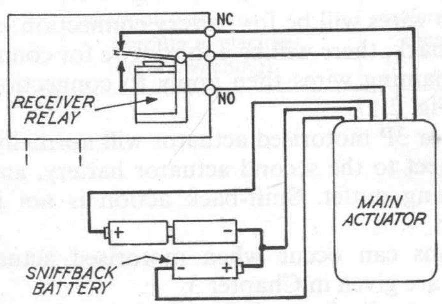


FIG. 2.16

Where a switching facility is provided on the main actuator (as is usual), a secondary actuator is connected directly to the switching outlet and the relay armature contact. It is also usual to feed the secondary actuator via a second actuator battery, which is commonly of lower voltage than the main actuator battery – Fig. 2.17. There are several possible variations in physical wiring, which may be specific to the combination used, and thus in the case of matching units which do not have pre-wired plugs and sockets the actual wiring instructions must be followed closely. Wire colours are no general guide since different manufacturers may use different colour coding.

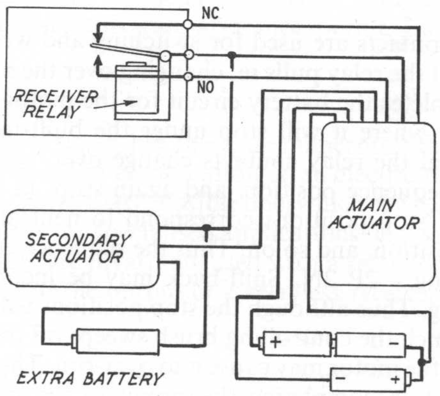


FIG. 2.17

The following general notes can, however, be a useful guide.

A main motorised actuator will have at least six wires emerging, and may have as many as nine.

(a) Three of these wires will be for connection to the relay contacts (NO, armature and NC).

(b) At least two wires will be for battery connection; and if the actuator incorporates sniff-back, there will be a third wire for connection to the sniff-back battery. Remaining wires then apply to connections to a secondary actuator, e.g. see Fig. 2.17.

A secondary 2P or 3P motorised actuator will normally have three wires, two of which connect to the second actuator battery, and the other to the main servo switching outlet. Sniff-back action is not incorporated in a secondary actuator.

Further variations can occur when motorised actuators are used in cascade. Examples are given in Chapter 3.

Note: see also Appendix for typical wiring diagrams.

Table I Basic escapement types and applications

Description of type	*Application(s)*
Simple S/N 2P	main actuator for rudder-only secondary actuator for throttle control
Simple progressive 3P	secondary actuator for throttle control
Selective S/N 2P	main actuator for rudder, usually with 'quick blip' switching built in for controlling secondary escapement
Compound (selective) S/N 3P	main actuator for rudder, plus 'third position' for operating secondary control
Compound (selective) S/N 2P +trip	main actuator for rudder plus 'third position' trip movement for operating 'back elevator'

Table II Basic types of motorised actuators

Description of type	*Application*	*Remarks*
S/N 2P	rudder control	usually selective action may also incorporate 'quick blip' switching facility
Progressive 2P	secondary control (throttle or electric motor switching)	
S/N compound 3P	main actuator for rudder	incorporates 'quick blip' switching facility plus selective 'third position' switching for controlling one or two secondary actuators
Progressive 3P	secondary control (throttle or electric motor switching)	preferred type for electric motor switching

CHAPTER THREE

AIRCRAFT CONTROLS

The one control *essential* to be able to command piloted response from a free flying model aircraft is *directional control*. This means that the *essential* service provided by single-channel radio must be *rudder control*. Any other services which can be provided by extending sequence switching must be regarded as secondary controls, and must not have a critical affect on the flight performance since they cannot be signalled simply and rapidly. The one exception is 'quick-blip' signalling to work one other service via a second actuator on a 'changeover' basis – normally throttle control.

This necessary limitation of control to one main service – rudder – places a certain premium on model design. Response to rudder movement in flight is twofold. Rudder movement induces the model to turn in the direction signalled – e.g. right rudder will give right turn, and vice versa. Turning will make the model roll into a banked attitude – and possibly skid sideways as well. At the same time the nose will drop, putting the model into a dive. Holding on rudder, in fact, will merely put the model into a spiral dive. Thus a reasonably 'flat' turn can only be produced by applying rudder momentarily and then returning to neutral, repeating this command as necessary. This 'piloting technique' is described in Chapter 5.

Rudder-only

The design of a satisfactory rudder-controlled model has to be 'balanced' to reduce unwanted reactions as far as possible. Thus if rudder control is applied to an ordinary free flight model, which usually has a high reserve of automatic stability, the amount of roll into the turn, and in the opposite direction on release of signal, will tend to be excessive. The controlling factor in this respect is usually the dihedral angle on the wing. A large dihedral, necessary for 'free flight' stability, does not produce good response to rudder control.

On a single-channel radio controlled model, therefore, the dihedral is made smaller to reduce the amount of roll reaction following application of rudder. At the same time this will reduce the 'nose dropping' tendency on going into a turn, and the 'nose rising' tendency on recovery when the rudder is returned to neutral. There is a limit to how far this can be carried as with insufficient dihedral the model will skid and sideslip, and may not have

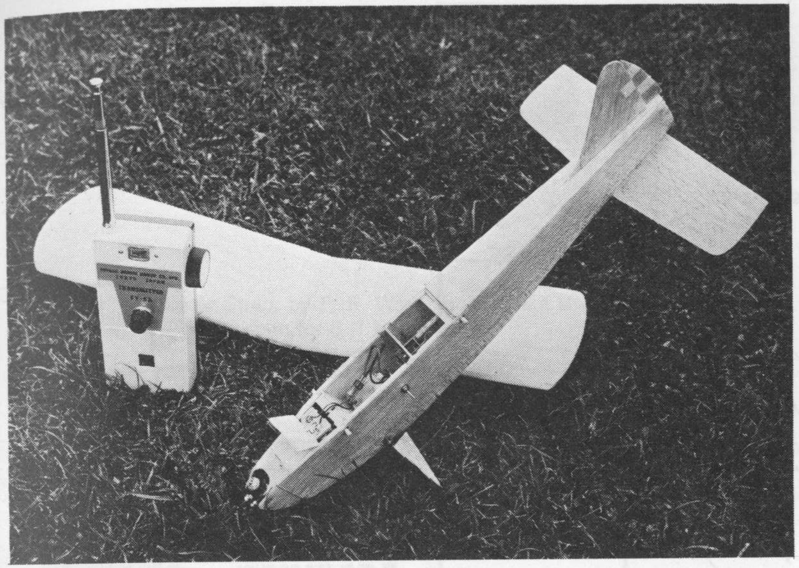


Plate 18 Basic control for single-channel aircraft is rudder. Installation shown is rudder-only, driven by a simple escapement

sufficient automatic stability to be stable in normal flight. In practice, therefore, dihedral can only be reduced to the point where sufficient automatic stability still remains for normal 'rudder neutral' flight, since the model will operate *most* of the time under this condition.

Working with a smaller wing dihedral places a premium on other proportions of the model – particularly the fin and rudder area – and also the rigging angles and 'trim'. Because some automatic stability is necessary, a high wing layout is usually adopted and proportions normally follow on the lines shown in Fig. 3.1 and Table III. Other design data are summarised in Tables IV and V. Of course, there are many variations possible, and even different layouts; but designs which are radically different can show distinct limitations in control and response.

Rudder movement

It will be noticed that only a comparatively small rudder area is required, because of the strong effect of rudder as a control. The optimum rudder *movement*, however, is less readily defined as this depends on the 'pilot' as well as the model design.

This is further complicated by the fact that more rudder movement is required to produce a turn in gliding flight than when the model is under power. Beginners usually have to start with small rudder movements in

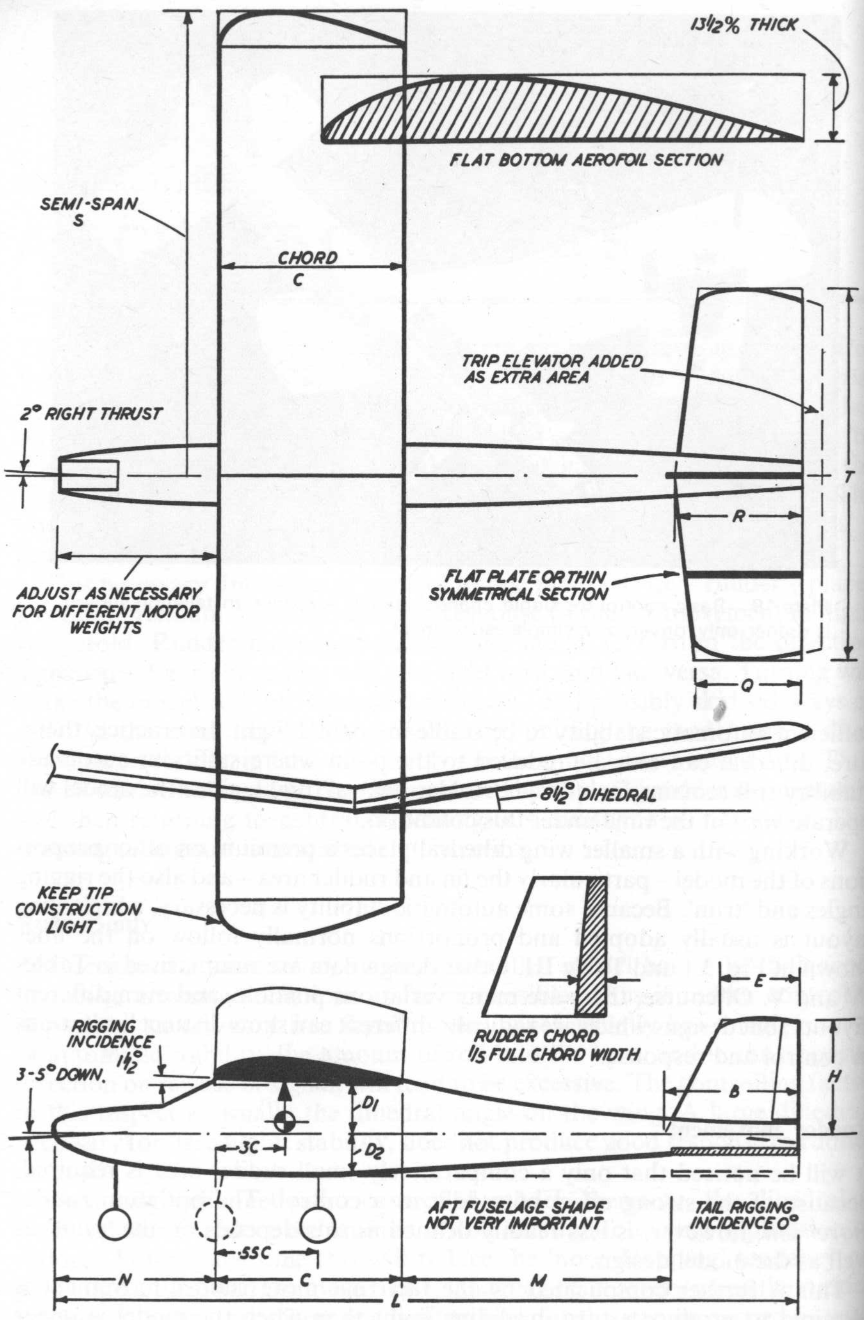


Fig. 3.1 Aircraft design layout (see also page 37)

Plate 19 Shoulder Strap, by P. R. Williams. This is a single channel model of great strength – 37 in. span for 8–1·5 cc engine

order to avoid over-control under power, but the more experienced the pilot the more rudder movement he can use – see Chapter 5.

Rudder-plus-throttle

A surprising amount of control can be available with 'rudder-only', including loops – again see Chapter 5. But the addition of secondary controls can give further scope. Here experience has clearly indicated the *preferred* controls. Thus *throttle control* always has preference over elevators as a second service, operated by a 'quick-blip' signal.

The reason for this is that throttle control is very useful (speed changeover from slow to fast, and vice versa, can be used to control the height of a model, for example); and is also *non-critical*. The model is still 'safe' under rudder control whether the speed is 'slow' or 'fast'.

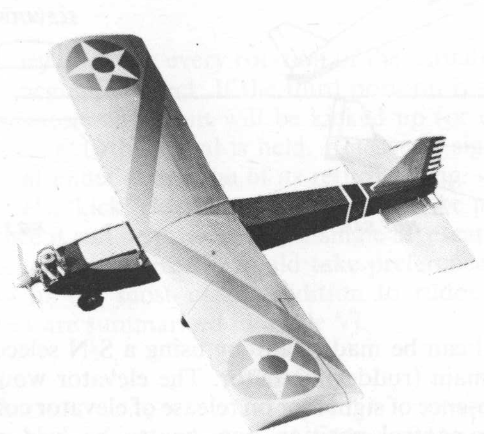


Plate 20 Sleeker, a good performer, designed by P. Cook and M. Ashby

Rudder-plus-elevator

This is not necessarily the case with elevator control. There is only one 'safe' elevator position – neutral. If operated via a second 2P actuator, the elevator would have one 'safe' position (normal flight) and one 'unsafe' position (elevator up or down) – Fig. 3.2. It would have to be *signalled* out of this position to restore the model to normal flying attitude. Full elevator movement, operated by a 3P actuator would be even worse – one 'safe' and two 'unsafe' positions (elevator up and elevator down) – Fig. 3.3. Also it would be difficult to remember whether 'up' or 'down' followed neutral elevator.

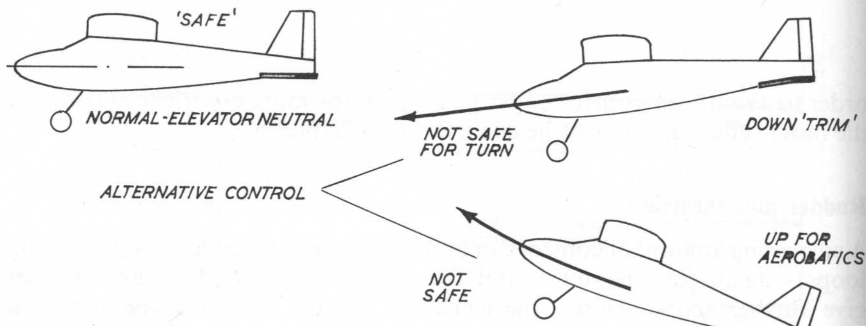


FIG.3.2

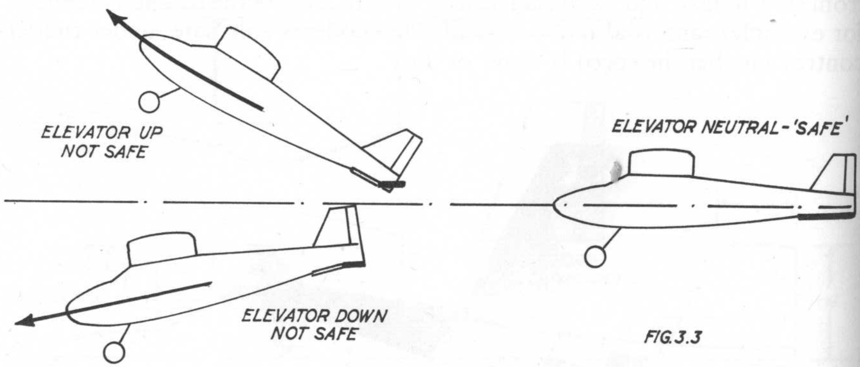


FIG.3.3

Elevator control can be made 'safe' by using a S/N selective actuator in cascade with the main (rudder) actuator. The elevator would then always be neutral in the absence of signal (or on release of elevator command signal). However, elevator control position now has to be *held* on (like rudder control), calling for very cumbersome signalling. Thus press-and-hold, and

press-release-press-and-hold are reserved for rudder. Elevator movements are thus signalled by:

press—release—press—release—press and hold elevator up (or down)
press—release—press—release—press—release—press and hold elevator down (or up)

This system can be worked, but experience has shown that it is not a very practical one. Various attempts have been made to simplify signalling by incorporating a coding device on the transmitter which automatically generates the sequence signal required in response to movement of a stick up or down, but there is still the possibility of a signal being 'skipped', upsetting the sequence and thus giving a false command.

'Kick' elevator

A more practical form of elevator control which has emerged in 'kick elevator'. Basically this utilises the third position of a S/M 3P compound actuator (normally an escapement) to contact a 'kick lever' connected to the elevator – see Fig. 3.4 and Fig. 4.14. The elevator movement will thus be

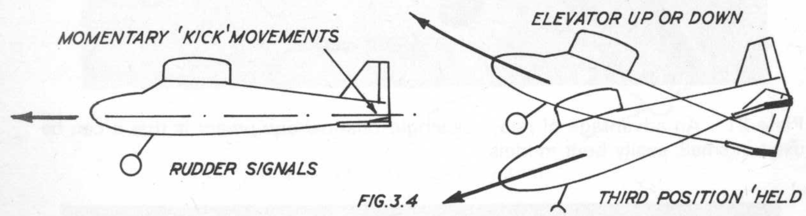


FIG.3.4

given a momentary 'kick' on every rotation of the actuator back to neutral, which will have negligible effect. If the third position is signalled and held, however, the elevator movement will be kicked up (or down) and stop in this position as long as the signal is held. Release of signal will return the elevator to neutral under the action of its return spring.

On small models, 'kick' elevator plus rudder may be preferred to rudder plus throttle, since it can be provided by a single 3P escapement, of suitable design. In all other cases, throttle would take preference over any form of elevator control as the most useful addition to rudder control. Specific recommendations are summarised in Table VI.

Aileron control

Ailerons produce more gentle turns than rudder, and have indeed been used successfully on some single channel models instead of rudder control. This

Plate 21 An advantage of relayless single-channel equipment is that it can be used in small, easily built models

Plate 22 Biplanes can be really small

must be regarded as the exception rather than the rule, however, although it can prove an interesting field for further experiment, essentially intended for calm weather flying. Ailerons, for example, cannot be expected to give anything like the same degree of directional control, or height control, as rudder.

A further interesting field for experiment is *coupled* ailerons and rudder, known as CAR. This can be applied to larger models, where separate motorised actuators are used to work ailerons and rudder, the actuators being connected in parallel electrically to respond simultaneously – Fig. 3.5. The same mode of working could be achieved with a single actuator driving separate aileron and rudder linkages, although this is usually less practical in arrangement.

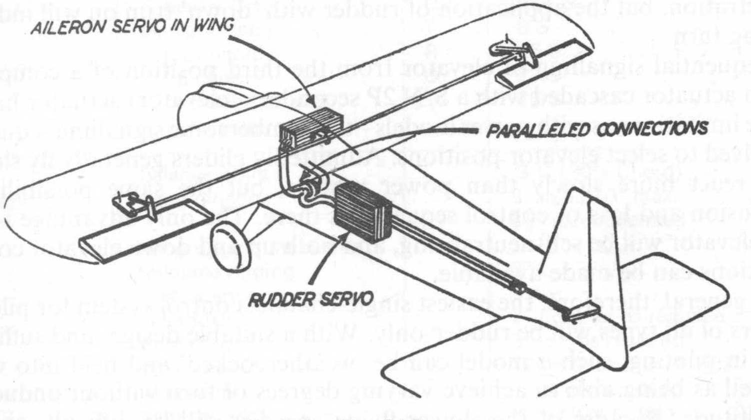


Fig. 3.5 The CAR system

The CAR system is not generally to be recommended for single-channel working since smooth turns can only be obtained by a substantial reduction in rudder control effect. Once a turn is initiated by ailerons, for example, *opposite* rudder movement is really required to maintain a level turn.

Coupled rudder and elevators (CRE) are another possibility – on the basis that in a rudder turn the application of a little up elevator will prevent the nose from dropping. In practice this seems to have even more limitations than coupled ailerons and rudder.

Glider controls

Rudder is again the primary control for gliders. There is really no alternative and the majority of single-channel gliders are flown with rudder-only control.

This can pose considerable limitations when flying in winds, e.g. when trying to prevent the model continually losing ground downwind; and

particularly for slope soaring where the pilot has to maintain control in varying winds and conditions. The loss of height inherent with rudder turns can be disastrous.

A logical extension of single-channel control to gliders is elevator, although this will inevitably complicate piloting problems. To simplify command, and provide the fastest response, this should be operated by 'quick-blip', which can only give a changeover control, i.e. 'up' and neutral; or 'down' and neutral. Elevator movement used should then correspond to 'trim' effect only.

A choice must then be made as to which is the most useful secondary control – 'up' trim or 'down' trim. 'Up' trim will be useful to counter loss of height in turns or to tighten up a turn, but will be of little value otherwise. 'Down' trim can be used to increase the flying speed and provide better penetration, but the application of rudder with 'down' trim on will induce a diving turn.

Sequential signalling of elevator from the third position of a compound main actuator cascaded with a S/N 2P secondary (elevator) actuator has the same limitations as with power models – the cumbersome signalling sequences involved to select elevator positions. Admittedly gliders generally fly slower, and react more slowly than power models, but the same possibility of confusion and loss of control sequence is there. The only advantage is that the elevator will be self-neutralising, and both up and down elevator control positions can be made available.

In general, therefore, the easiest single-channel control system for piloting gliders of all types will be rudder-only. With a suitable design, and sufficient skill in piloting, such a model can be 'weathercocked' and held into wind, as well as being able to achieve varying degrees of turn without undue loss of altitude. Because of the slower flying speed it will be difficult, or even impossible, to 'fishtail' to improve penetration (see Chapter 5); and satisfactory operation will definitely become more and more limited as wind speeds increase. This will be found particularly true in the case of slope soaring.

Table III

	Design feature	Key	Value *Related to Semi-span (S) unless noted otherwise*
Dimensions variable with model size	wing span		2 S
	wing chord	C	·4 S
	nose length	N	S/3
	tail moment arm	M	S/2
	fuselage length	L	approx. ·8 × span or 1·6S
	fin height	H	·25 S
	base chord at C/L	B	·35
	tip chord	E	·17 S or B/2
	fuselage depth:		
	above C/L	D1	·1 S
	below C/L	D2	·085 S
	tailplane span	T	·8 S
	root chord	R	·26 S
	tip chord	G	·23 S
	chord for parallel tailplane		·25 S
Fixed proportions	balance point		·3 C (30% Chord)
	wing dihedral		8° min., 10° max., 8½° recommended
	wing rigging incidence		+1½°
	tailplane rigging incidence		0°
	sidethrust		2° right, or as required
	downthrust		3°–5°, as required
	wing section – flat bottom		12½% thick min., 13½% recommended
	tailplane section		flate plate or thin symmetrical
	undercarriage position:		
	orthodox		under wing L.E.
	tricycle		main wheels ·55 C back from L.E.

Table IV Structural design

Structure	*Span (inches)* 20	28	36	42	48	54	60
Fuselage: Sheet box	X	X	X	X	X	X	X
Built-up, tissue covered	S	S	S	S			
Built-up, nylon covered				S	S	S	S
Glass fibre moulding	NS	NS	NS	NS	NS	NS	S
Wings: Built-up, tissue covered	S	S	S	S	S	S	S
Built-up, nylon covered	NS	NS	NS	NS	NS	S	X
All-sheet	X	S	S	S			
All-sheet, tissue covered	S	X	X	S			
Built-up, sheet balsa skinned	NS	NS	NS	NS	NS	S	S
Expanded Polystyrene			S	S	S		
Expanded Polystyrene – balsa skinned						S	S
Tailplane: Built-up, tissue covered	S	S	S	S	X	X	S
Built-up, nylon covered	NS	NS	NS	NS	NS	S	X
Solid sheet	X	X	X	X	S		
Fin: Built-up, tissue covered					S	X	X
Solid sheet	X	X	X	X	X	S	S

X = Recommended S = Suitable NS = Not suitable

Table V Worked out dimensions for single-channel models (Adjusted as necessary)

Layout dimensions (see basic plan)	*Span (inches)* 20	28	36	42	48	54	60
Semi-span S	10	14	18	21	24	27	30
C	4	5½	7·2	8·4	9½	10½	11
N	3–3¼	4–4½	5½–6	6½–7	8	9	10
M	5	7	9	10½	13½	12	15
L	16	22½	29	34	38	42	46
H	2½	3½	4½	5¼	6	6¾	7½
B	3	4·2	5·4	6·3	7·2	8·1	9
E	1½	2·1	2·7	3·15	3·6	4	4½
D_1	1½	1½	2	2¼	2½	3	3½
D_2	1¼	1¼	1½	2	2	2¼	2½
T	8	11¼	14½	17	19	22	24
R	2·6	3·65	4·7	5½	6¼	7	7¾
Q	2·3	3·2	4·2	4·8	5½	6¼	7
Chord for parallel chord tailplane	2·5	3¼	4½	5¼	6	6¾	7½

Table VI General recommendations for aircraft controls

Model size wingspan (inches)	Engine Diesel (cc.) Glow (cu. in.)	Working controls		
		Rudder	Throttle	Elevator
20–24	— ·020	escapement	—	'back elevator' can be added, using a single escapement
30	0·5 ·049	escapement with 'quick blip'	can be provided by secondary escapement, but may not be very effective	—
36	1·0 ·09	escapement or motorised actuator	— secondary actuator operated by 'quick blip'	—
42	1·5 ·15–·19	motorised actuator* or escapement	secondary actuator operated by 'quick blip'	not recommended
48	1·2–2·5 ·19	motorised actuator* or escapement	secondary actuator operated by 'quick blip'	not recommended
54	2·5–3·5 ·29	motorised actuator	secondary actuator operated by 'quick blip'	not recommended
60	3·5 ·35	motorised actuator	secondary actuator operated by 'quick blip'	not recommended

* preferred choice

CHAPTER FOUR

AIRCRAFT CONTROL INSTALLATIONS

The weight of a complete radio installation can form a substantial proportion of the total weight of a model aircraft, particularly in the case of smaller models. It is thus essential that the radio units are positioned in the fuselage to maintain the proper model balance. The disposition shown in Fig. 4.1 is (almost) universally adopted, regardless of the size of the model.

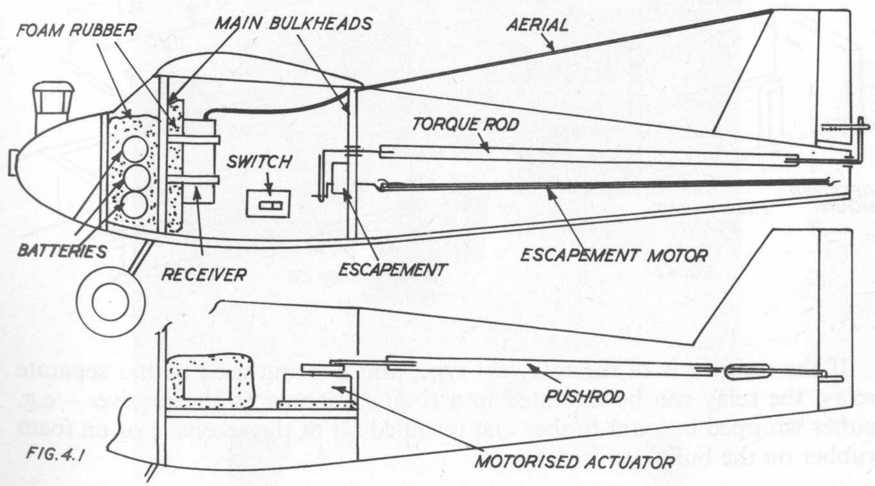


FIG. 4.1

Battery position

All *batteries* are grouped together and mounted forward of the receiver. The usual position is immediately behind, or immediately in front of, the firewall. They should be located in an oversize compartment or 'box', so that the battery 'pack' forms a fairly tight fit when wrapped in foam rubber and inserted. If dry batteries are being used, the batteries will require frequent removal and replacement. Thus the design of the compartment should allow for easy access. If nickel-cadmium batteries are used throughout, then

the whole battery pack can be considered as a permanent installation, provided each battery is wired to an external socket for plugging in a battery charger. Alternatively, to avoid this extra wiring, nickel-cadmium batteries can be removed for charging.

Receiver position

The *receiver* is mounted close behind the batteries. It does not usually matter whether it is mounted horizontally or vertically (or in any other position). Again it can be wrapped in foam rubber to fit into a boxed compartment; or mounted on a separate $\frac{3}{32}''$ ply bulkhead or tray – see Fig. 4.2. The bulkhead, or tray, can slide between guides glued to the fuselage sides or bottom, respectively, to allow the unit to be removed. The sponge rubber mounting is glued to the bulkhead (or tray), and the receiver glued to the rubber. Strapping can also be added, if thought necessary, in the form of rubber bands.

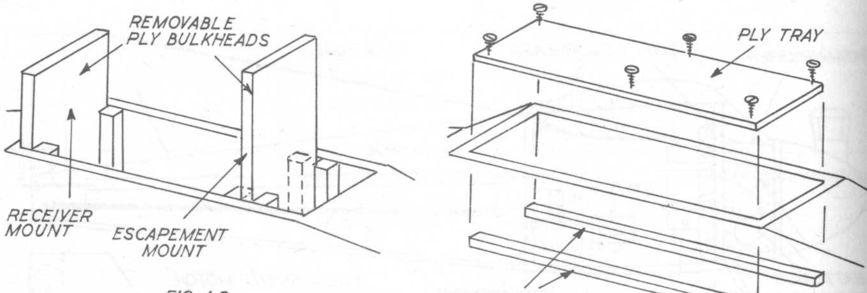


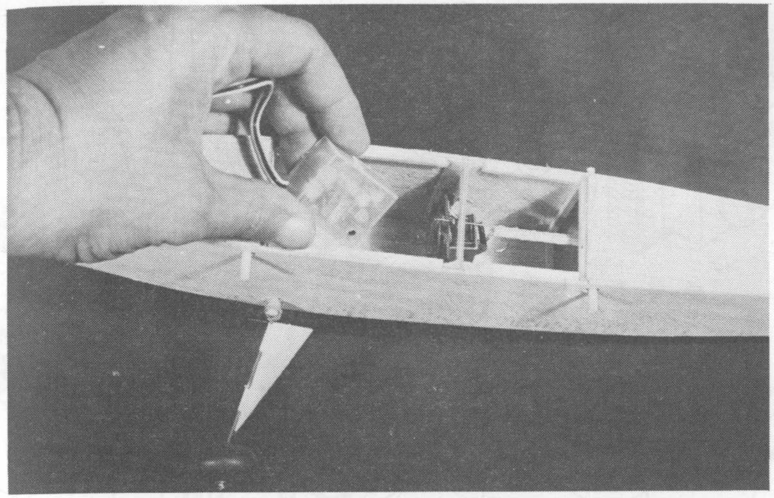
FIG. 4.2

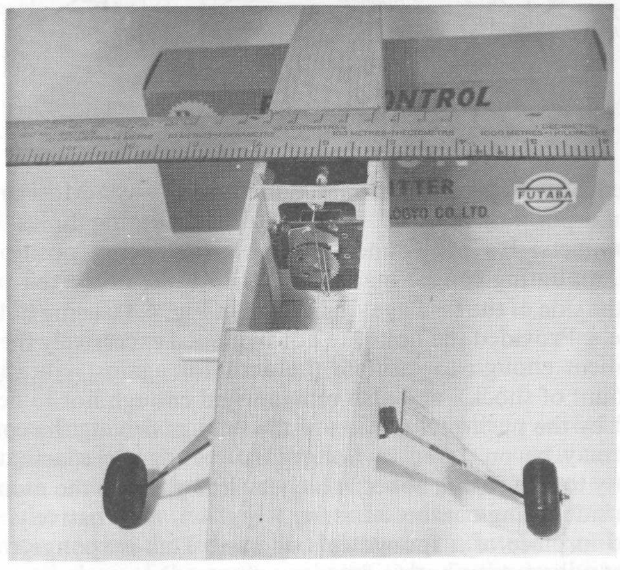
If the receiver is of the relayless type, and is being used with a separate relay, the relay can be mounted in a similar manner to the receiver – e.g. either wrapped in foam rubber and installed aft of the receiver; or on foam rubber on the bulkhead or tray.

Actuator mounting

The *actuator* is mounted still farther aft. In the case of an *escapement* the usual position is on a vertical ply bulkhead more or less immediately under the wing trailing edge position. This bulkhead should be of $\frac{3}{32}''$ ply, and can fit between guides to make it removable, like a receiver bulkhead mount. The bulkhead will usually be of sufficient size to accommodate one or two escapements, as required.

A motorised actuator is appreciably heavier than an escapement and so its optimum position should be found by trial. With the radio installation





Plates 23 and 24 Escapements are mounted vertically on a bulkhead

otherwise complete, the fuselage having the engine already fitted and the tailplane attached, the actuator can be laid in the fuselage and moved fore and aft to find the position which gives the correct or design balance point for the model – Fig. 4.3. The wing need not be fitted during this check as wing weight will have little effect on the final balance point.

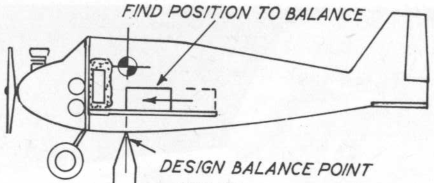


FIG. 4.3

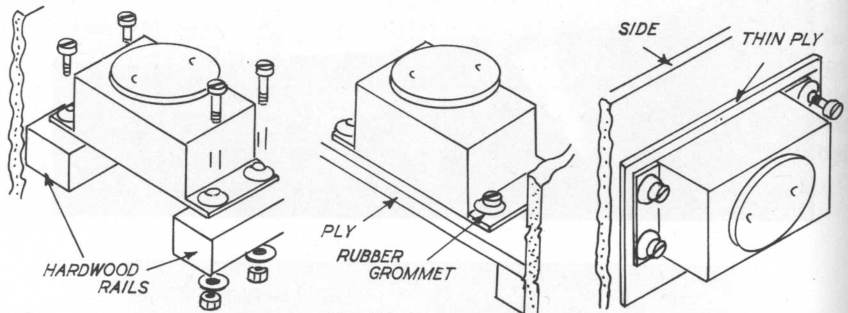


FIG. 4.4

Motorised actuators can be mounted in various ways. Most are enclosed in cases incorporating feet or flanges, with mounting holes fitted with rubber grommets. Having found a suitable 'balancing position' for the actuator(s), mounting can be made directly to rails, or a fixed ply tray, or directly to the side of the fuselage – as shown in Fig. 4.4 – using bolts through the grommets. Provided the bolts are not tightened excessively the mounting will be resilient enough to insulate the actuator against vibration (and a certain amount of shock), and also remain rigid enough not to be displaced fore and aft by the push-pull motion of the linkage driving the control(s).

Bonding may be preferred to bolting. In this case the actuator case is glued directly to stiff foam rubber, which itself is glued to the mounting tray (or fuselage side) using contact adhesive – Fig. 4.5. Alternatively, servo tape can be used in place of a sponge rubber base. This is sponge rubber strip with contact adhesive on both sides.

There are also other possibilities. For example, a sheet balsa compartment can be lined with foam rubber to accommodate the actuator as a tight 'sliding' fit, with provision to hold the actuator positively in place against vertical displacement (Fig. 4.6). The two main requirements, apart from optimum positioning are:

(i) Resilient mounting so that the actuator is insulated against vibration.
(ii) Positive location so that the actuator itself is not displaced by the push-pull reaction forces on the attached linkage.

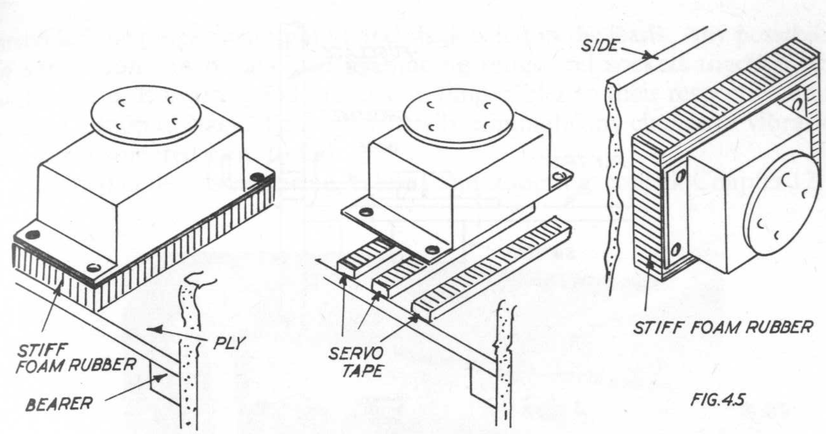


FIG. 4.5

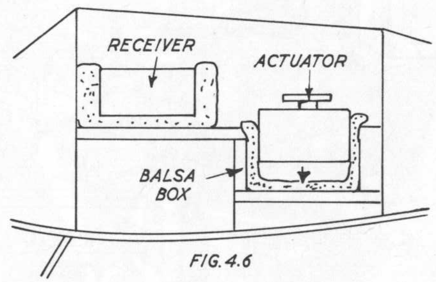


FIG. 4.6

Wiring installation

The electrical installation is completed by the wiring installation. Most modern single-channel equipment is pre-wired, which simply means that the receiver leads, actuator leads and battery connections are completed by plugging to the wiring harness. The latter includes an on-off switch, which is normally mounted on the side of the fuselage. A position should be chosen where it is well clear of the engine exhaust (e.g. on the opposite side to the engine exhaust), or waste fuel which may be blown back by the slipstream. To ensure that the switch is in a 'clean' position some modellers prefer to mount it inside the fuselage, operating it by an extension arm taken through the side of the fuselage – Fig. 4.7.

If the individual components are not pre-wired to plugs and sockets, then the same method of connection is recommended. That is, the receiver wiring should be soldered to a *plug*, and the actuator, switch and battery wiring to matching plugs and sockets as necessary to complete the connections

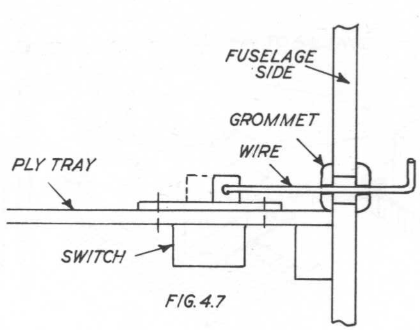


FIG. 4.7

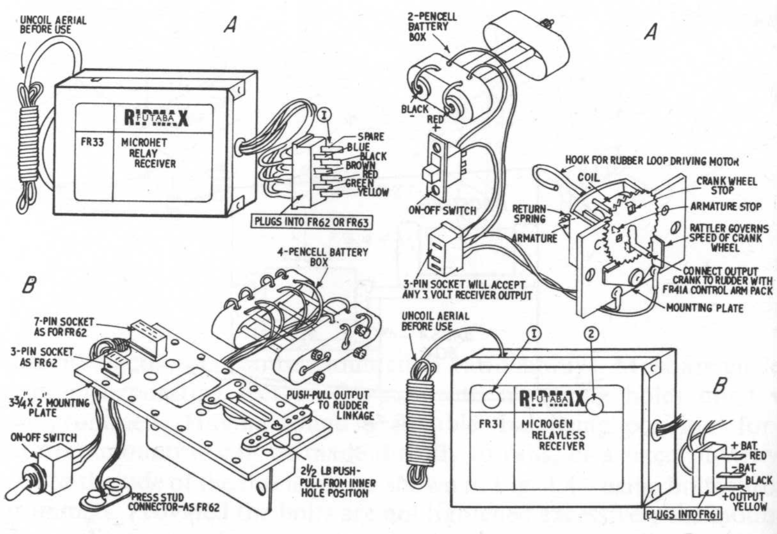


Fig. 4.8 Plug-together units (Ripmax-Futaba). Typical 7-pin connections (1) spare Black – receiver battery negative, Red – receiver battery positive, Yellow – earphone test point (-ve), Blue – relay 'Make' contact (N/O), Brown – relay 'Break' contact (N/C), Green – relay armature contact (C)

(Fig. 4.8). Note that battery wiring should *always be connected to a socket*. This will eliminate the possibility of accidental shorting of a battery pack when disconnected.

The advantage of plug-and-socket connections, as opposed to 'integral' wiring, is that it makes it easy to remove and disconnect any one unit in the circuit, if necessary. Miniature plugs and sockets are 'polarised', so they cannot be fitted together the wrong way round – so there is no chance of reversing wiring connections when re-plugging together, provided the original connections are correct. Plug and socket connections are also highly reliable,

provided the plugs are a tight fit and slack is left in the leads. Any possibility of separation can be avoided by binding plugs and sockets together, e.g. with cotton. It is also good practice to bind cables to their respective units, leaving a loop of slack. This will virtually eliminate any chance of vibration causing a soldered joint to fail.

For further details on wiring, cabling and soldering, consult Chapter 12.

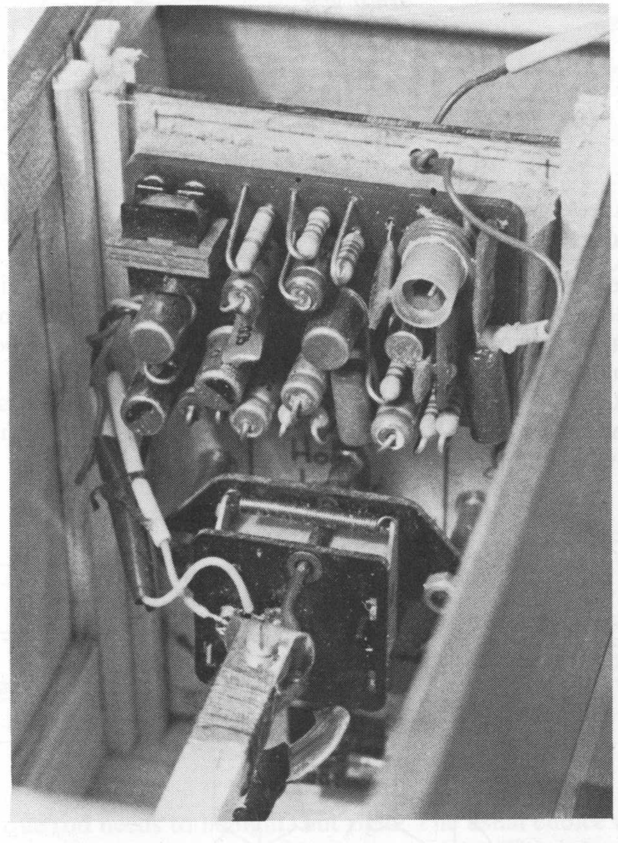


Plate 25 In this installation receiver is mounted above escapement on same bulkhead. This calls for complete suppression of the escapement, e.g. by bonding (see Chapter 11)

Aerial wire

The aerial wire must always be kept quite separate from the rest of the wiring, and particularly the actuator wiring which carries relatively high and changing currents. The aerial wire should be taken out through the side, top or bottom of the fuselage in as direct a path as possible, leaving a little

slack inside the fuselage, and then in as straight a line as possible. The usual method is to take the aerial to the top of the fin, where it can be attached by a pin passing through a knot tied in the wire and any remaining length left to fall slack – Fig. 4.9. Note how a knot in the aerial wire can also be used to provide slack between the receiver and the fuselage side.

See also the section in Chapter 11 on *Bonding*.

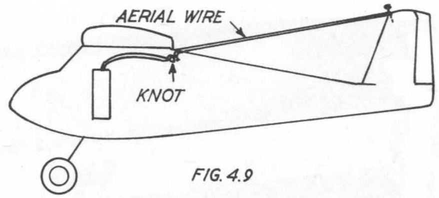


FIG. 4.9

The Mechanical Linkage

Escapement movements provide a rocking-motion output via a *yoke*, which is either incorporated in the construction of the escapement or has to be made in the form of a bent wire loop fitted in a suitable bearing and mounted on the same panel as the escapement, immediately above the escapement crank – Fig. 4.10. If a yoke has to be made to fit an escapement, note that the length of the loop must be slightly greater than the full up-and-down 'throw' of the crank to work without binding.

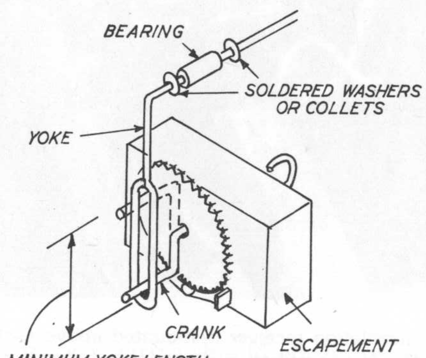


FIG. 4.10

The yoke motion is transmitted to the end of the fuselage via a *torque rod*. A wire loop fitting secured to the other end of the torque rod can then transform the yoke motion into rudder movement – the complete set-up being shown in Fig. 4.11. Figs. 4.12 and 4.13 show how actual rudder movement obtained is dependent on the position of the rudder yoke. An alternative rudder linkage is shown in Fig. 4.13.

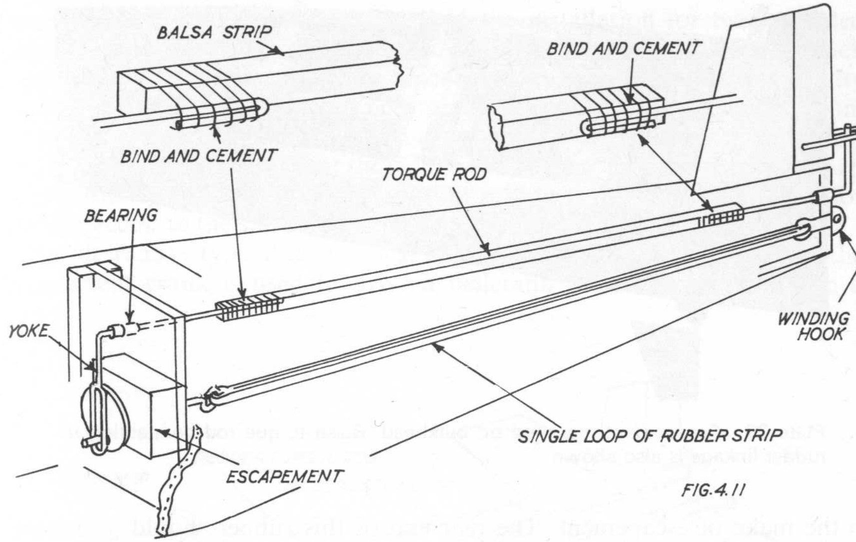


FIG. 4.11

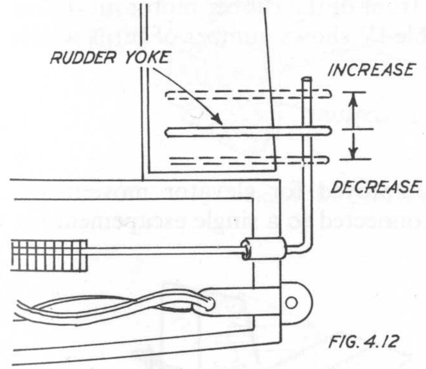


FIG. 4.12

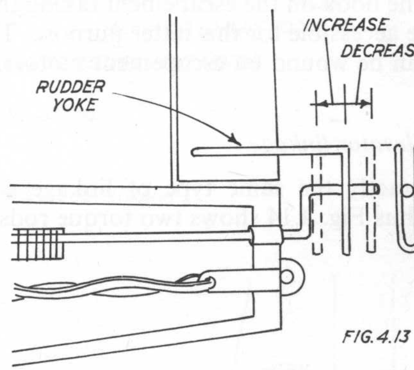


FIG. 4.13

The torque rod needs to be light, but rigid. The usual choice is $\frac{3}{16}''$ square hard balsa (or $\frac{1}{4}''$ square hard balsa for large models). This is securely bound to the yoke spindle at one end, and the rudder-operating fitting bound to the other end. This wire has to be located and supported by a simple bearing in the sternpost of the fuselage.

Escapement motors

Also shown in Fig. 4.11 is the escapement drive motor. This is invariably a single loop of rubber strip, $\frac{1}{8}''$ or $\frac{3}{16}''$ wide (or sometimes $\frac{1}{4}''$ wide), according

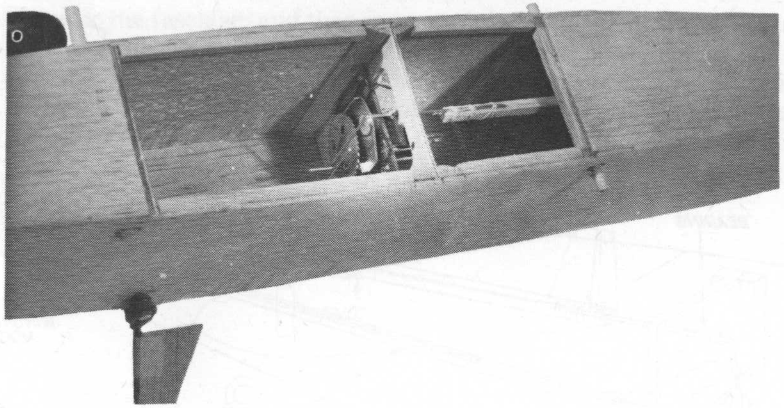


Plate 26 Escapement mounted on bulkhead. Balsa torque rod connecting to rudder linkage is also shown

to the make of escapement. The rear end of this rubber should terminate on a winding hook fitted to a detachable plug which can be withdrawn to wind turns onto the rubber; and also to replace a rubber motor if necessary. The hook on the escapement taking the front of the rubber motor must also be accessible for this latter purpose. Table IV shows number of turns which can be wound on escapement motors.

Elevator linkage

Exactly the same type of linkage is employed for elevator movements. Thus Fig. 4.14 shows two torque rods connected to a single escapement for

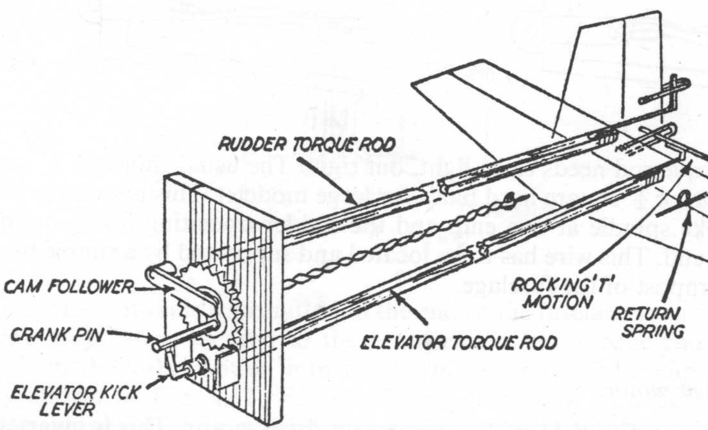


Fig. 4.14 Elevator linkage

'kick elevator' operation; and Fig. 4.15 the installation for two cascaded escapements providing rudder and elevator control. In the latter case each escapement requires its own rubber motor, which may present some difficulty in finding suitable termination points at the rear end. If there is not room to accommodate both rubber motors on the fuselage sternpost, then they can be terminated on hooks in the side of the fuselage near the rear end. Each termination point can be in the form of a hinged or removable hatch for gaining access to the end of each motor for winding, or replacement.

An alternative type of mechanical linkage is shown in Fig. 4.16. Here the escapement crank is used to drive a bellcrank movement, resulting in a

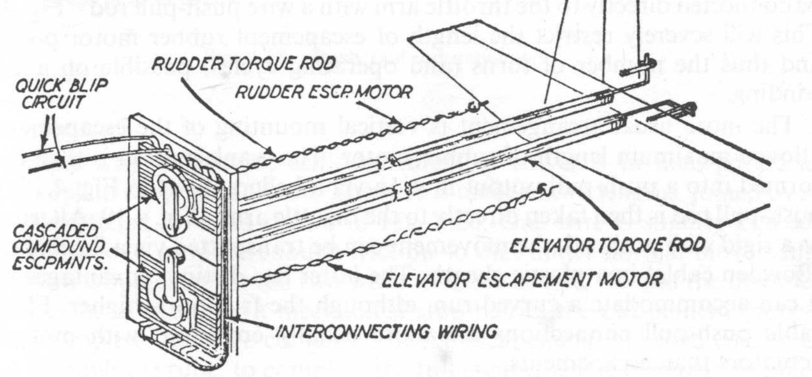


Fig. 4.15 Elevator and rudder linkage

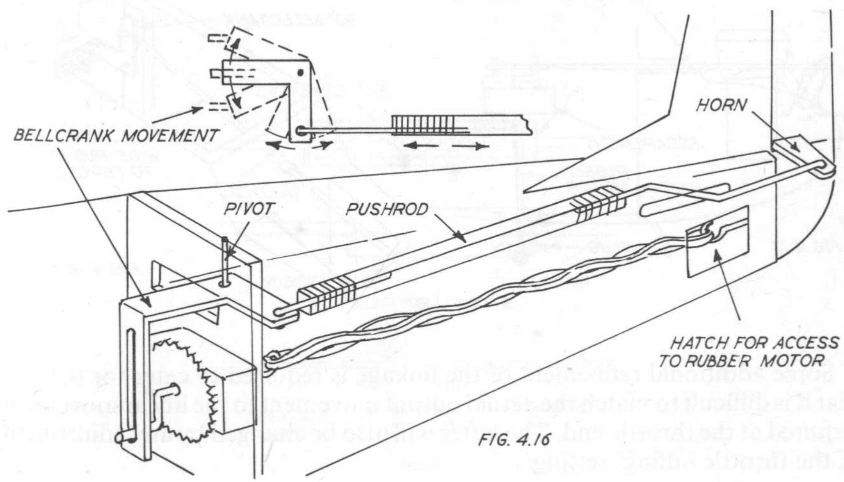


FIG. 4.16

push-pull final movement. The torque rod thus becomes a push-pull rod, and the movement is taken to a rudder horn instead of the wire loop and pin linkage as before. The rear end fitting is cranked to take through a slot in the side of the fuselage. This has the advantage of eliminating the need for a rear bearing, and also means that the rudder can be carried to the full depth of the fuselage sternpost if required (e.g. on a scale model).

Throttle control linkage

The coupling of a secondary escapement to operate a throttle requires a rather different form of mechanical linkage. Since the number of times a throttle control needs to be operated in a single flight is usually small, it may be acceptable to mount the escapement vertically, so that the crank can be connected directly to the throttle arm with a wire push-pull rod – Fig. 4.17. This will severely restrict the length of escapement rubber motor possible, and thus the number of turns (and operating cycles) possible on a single winding.

The more usual arrangement is vertical mounting of the escapement to allow a maximum length of rubber motor. The crank motion is then transformed into a push-pull output motion via a bellcrank, as in Fig. 4.18. The push-pull rod is then taken directly to the throttle arm – Fig. 4.19. Alternative to a rigid wire pushrod, the movement can be transmitted via a flexible cable (Bowden cable) in a plastic sheath. The latter has distinct advantages since it can accommodate a curved run, although the friction is higher. Flexible cable push-pull connections are more usually employed with motorised actuators than escapements.

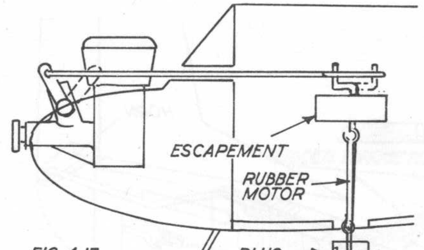


FIG. 4.17

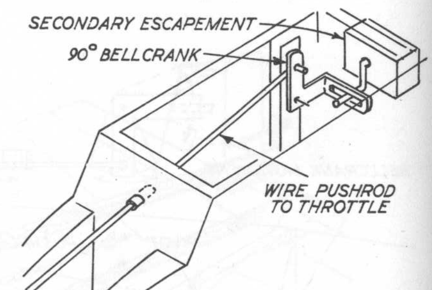


FIG. 4.18

Some additional refinement of the linkage is required to cater for the fact that it is difficult to match the actual output movement to the linear movement required at the throttle end. The latter will also be changed by any adjustment of the throttle 'idling' setting.

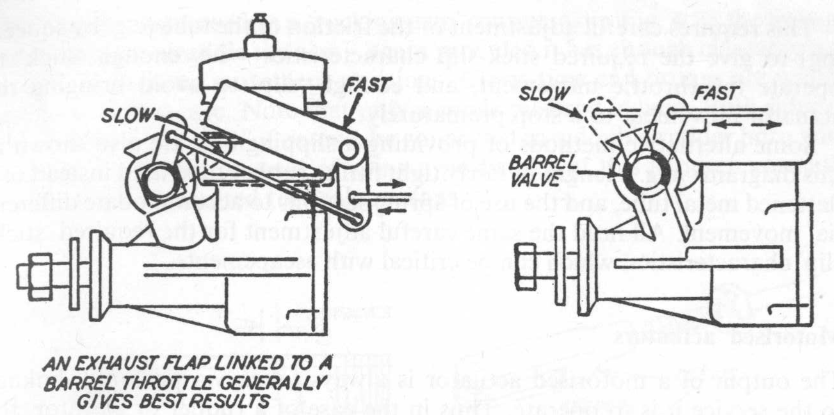


Fig. 4.19 Push/pull rod movement

A simple way to provide self-adjustment of travel is to incorporate a slipping link in the push-pull rod. The wire is made in two lengths, joined by a piece of flattened tube, as shown in Fig. 4.20. One wire is slightly kinked inside the tube to produce enough friction so that under normal movement the friction is sufficient for the two wires to move as one. Should the throttle movement be arrested by a mechanical stop before the escapement movement is complete, the wire connected to the escapement will then continue to slip through the tube, to complete the full escapement movement. On the return motion the two wires first move as one. Once the full throttle movement has been taken up the escapement wire continues to slide through the tube to take up the full escapement movement.

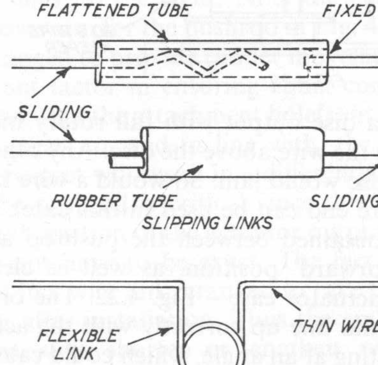


FIG. 4.20

This requires careful adjustment of the friction of the tube (e.g. by squeezing) to give the required stick-slip characteristics – i.e. enough 'stick' to operate the throttle movement, and enough 'slip' to avoid bringing the actuator movement to a stop prematurely.

Some alternative methods of providing a slipping link are also shown in this diagram – e.g. a length of fairly tight fitting rubber tube used instead of a flattened metal tube, and the use of spring sections to accommodate differential movement. All need the same careful adjustment for the required 'stick-slip' characteristics, which can be critical with escapements.

Motorised actuators

The output of a motorised actuator is always taken via push-pull linkage to the service it is to operate. Thus in the case of a rudder or elevator, the control surface movement is obtained by connecting the pushrod to a control horn. The pushrod can again be of square section balsa strip, with wire end fittings bound in place. Since the actual end connections are only loosely pivoted it becomes necessary to ensure that they cannot jump out accidentally, and so disconnect the movement. This can be done by bending the ends of the wires at right angles, or by using light wire 'keepers' bound to the wires, as shown in Fig. 4.21. Proprietary clips and keepers are also available for use with wire end fittings to lock them in place with simple pivot mounting. Proprietary pushrods are also readily available with matching end fittings (normally also providing length adjustment), but these are not necessarily suitable for the type of actuator concerned.

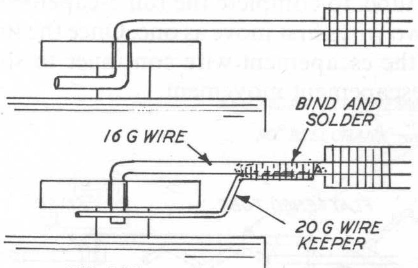


FIG. 4.21

If the actuator has a disc output with full rotary motion a simple 'pin' fitting is required, with the wire above the disc. Any other type of end fitting which 'straddles' the disc would jam. So would a wire keeper (which means that only a joggled wire end can be used in this case). It is also important that full clearance is obtained between the pushrod and actuator disc or casing in the most 'forward' position, as well as clearance between the joggle and top of the actuator case – Fig. 4.22. The other important thing is that the linkage should line up correctly with the actuator, not have the push-pull action operating at an angle, which could cause binding and overload the servo motor.

Where the actuator has a 'rocking arm' output, as in Fig. 4.23 the linkage end fitting can straddle the arm – again provided it has enough clearance not to bind at extreme movement positions. Clevis-type end fittings are widely preferred in this case. Note that only a single pushrod is used. Both sides of the rocking arm could, of course, be connected to a double rudder horn with thin wire or thread, instead of using a pushrod, but this is never normally done, except if required for scale reasons.

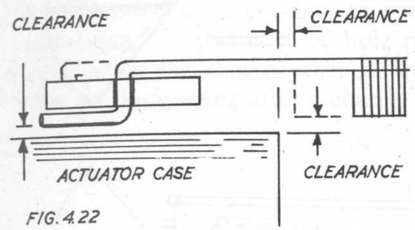


FIG. 4.22

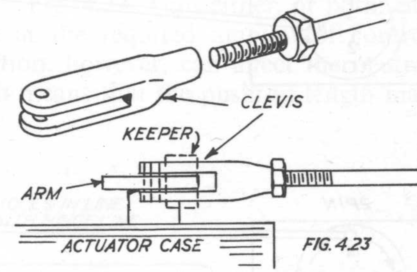


FIG. 4.23

Push-pull geometry

If an actuator with a disc output is a 2P 2N type, i.e. has two neutral positions, 'effective length' of the pushrod will be slightly different in each of these neutral positions, so that the control surface itself will have two distinct neutral positions. Normally, however, motorised actuators are of the 1N type, when this does not apply. This time, though, the actual *movements* may be unequal. These geometric effects are illustrated in exaggerated form in Fig. 4.24. They are not usually significant in practical installations where the differential movement is usually quite small. It can also be helpful to have slightly more rudder movement in one direction than another on a power model, e.g. to offset the motor torque effect. This would favour providing rudder movement 'bias' to the right. Note the effect of a straight run as opposed to a crossover run for the pushrod in Fig. 4.25. Normally, however, the geometry is arranged to provide rudder movements as equal as possible.

Another important factor in ensuring equal control movement in both directions is to ensure that the attachment hole(s) in the horn for the pushrod are truly at right angles to, and in line with, the rudder hinge line. Any deviation in either respect will result in a differential movement.

The length of the pushrod is critical since this lines up neutral control position with neutral position of the actuator output (arm or disc). However initial length does not have to be exact. The fact that the aft end of the pushrod terminates in a wire link, cranked to take through the fuselage side permits adjustment after installation. Thus the cranked bend angle can be increased or decreased to shorten or lengthen, respectively, the effective length of the pushrod linkage, Fig. 4.26. Adjustment is even simpler with

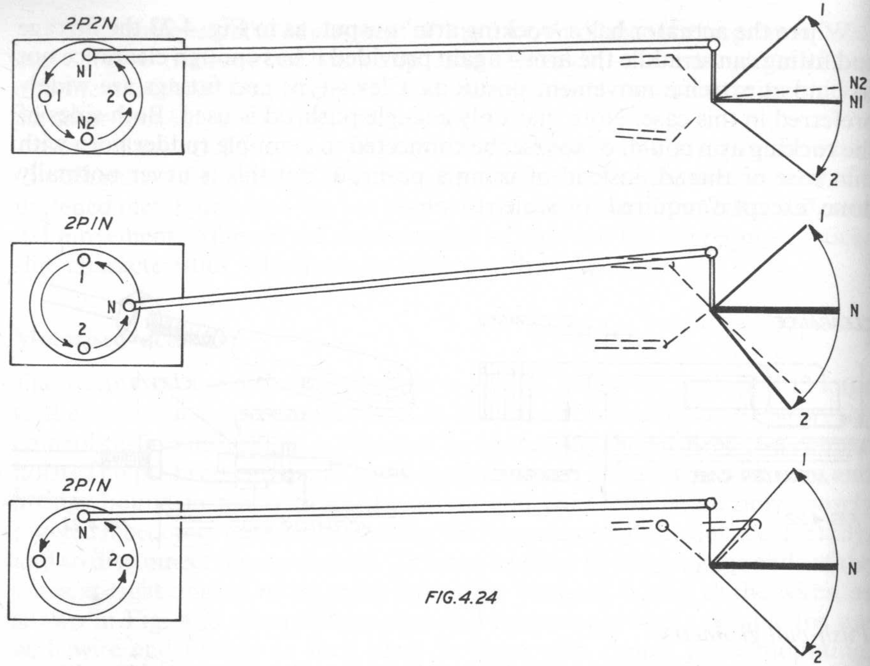


FIG.4.24

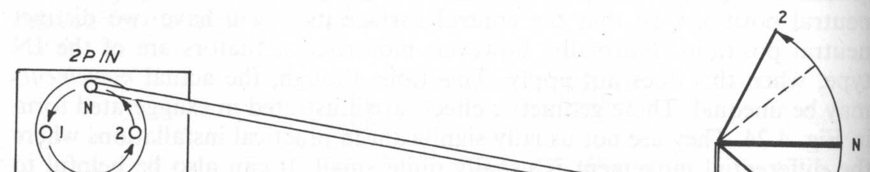


FIG.4.25

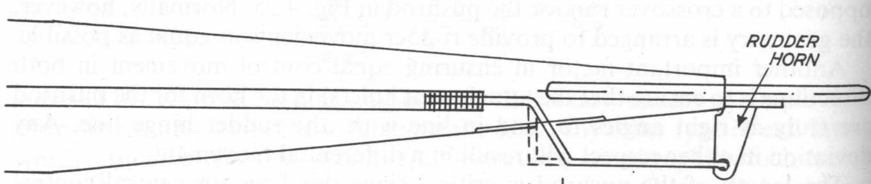


FIG.4.26

proprietary pushrods and end linkages since one (or both) ends are usually threaded and the corresponding fitting can be screwed in or out to adjust length.

Adjustment of control movement

The actual movement of the control surface can also be adjusted readily Both the actuator output disc (or arm) and the control horn are usuall made with alternative hole positions, into which the end links can be fitted In the case of the actuator output movement, the outermost hole gives mos pushrod travel movement. Moving the link to an inner hole decreases th pushrod travel. At the horn end the opposite is the case. The outermos hole gives least control surface movement. Moving the end link to an inne hole increases the control movement – Fig. 4.27. Thus either, or both, ca be adjusted, as necessary, to arrive at the required amount of contro movement. Adjustment of hole position, however, can affect the neutra position of the control surface, which means that the pushrod length ma also need adjusting after a change.

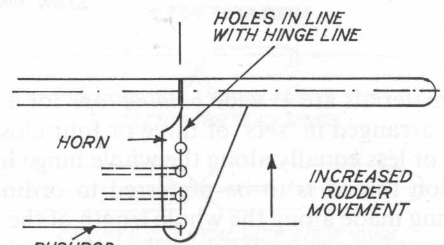


FIG. 4.27

Elevator control from a motorised actuator is treated in exactly the sam manner as for rudder – i.e. with a pushrod linkage connecting to the elevato horn.

The output movement of a secondary motorised actuator for throttl control can be treated in the same manner as described for escapements, an any rigid linking will require the inclusion of a slipping link (the rubbe tube type is usually the simplest, and one of the most effective). With flexibl cable push-pull linkage to a throttle movement it may be simpler to arrang for sufficient length of unrestrained cable to be included to accommodat extra 'push' movement by bowing the cable.

With motorised actuators it is *particularly* important to ensure that link ages cannot jam, and that friction is kept to a minimum, as otherwise th actuator motor and/or switching circuits can be damaged because of th high currents resulting. Proper alignment of linkages is not necessaril restricted to the actuator end – the control horn end can be equally critical thus a raked control surface hinge line is to be avoided as this puts the plane o motion of the control horn at an angle to the pushrod movement – see Fig 4.24. If a raked hinge line is necessary (e.g. for scale appearance), then a ball-and-socket type link end should be used capable of providing universa movement and relieving the pushrod from bowing stresses.

Control surface hinges

The hinging of rudders and elevators on single-channel models is quite straightforward. The two simplest – and cheapest – types of hinge are the *tape* and *stitch* – Fig. 4.28. Either can be used with 'square' hinge line edges, or chamfered edges. The latter gives a truer movement, but this is not a critical point on single-channel controls.

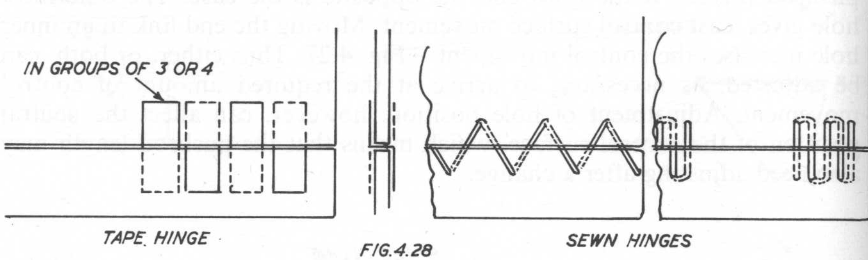


FIG.4.28

Recommended materials are $\frac{1}{2}''$ wide *binding tape* for a tape hinge. Individual hinges can be arranged in 'sets' of three or four close together; or as a series spaced more or less equally along the whole hinge line. In the case of a stitched hinge, nylon thread is to be preferred to ordinary carpet thread, angled stitching being made along the whole length of the hinge line.

Proprietary alternatives are prefabricated mechanical hinges (which are simply glued and/or pinned in place); and plastic strip material. The latter is intended to be used in small strips, inserted in slots cut into the edges of the two surfaces to be hinged. The hinge material can be smeared with contact adhesive to glue in place, but mechanical locking is also recommended. This is done by drilling holes through the hinge positions and then inserting short lengths of cocktail sticks smeared with balsa cement. These are cut off flush – Fig. 4.29. The best material for hinge strips of this kind is *polypropylene*. Other plastic sheet materials are, however, used and sold for this purpose. Plastic sheet hinges are not as 'free' as the other types mentioned, however. Thus tape or stitched hinges, or mechanical hinges, should be used with escapements.

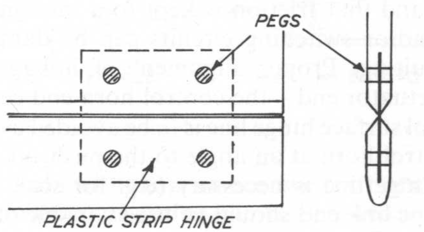


FIG.4.29

Hinge joints should be 'tight', but move freely. That is to say, the two hinged surfaces should butt together closely, but with easy movement provided by the hinge action – Fig. 4.30. Hinge movements are often accidentally stiffened by paint or dope finishes applied after assembly, and may be difficult to free again. It is best, if possible, to fit hinges after finish painting, etc. Either the stitched hinge or the plastic sheet hinge is best in this respect. Tape hinges are normally fitted before final covering and/or painting and thus are very liable to be stuck up later. Cement used to secure the tapes can also get into the hinge and stiffen the action, although this can usually be relieved by 'breaking' the hinge free by applying excess movement in both directions.

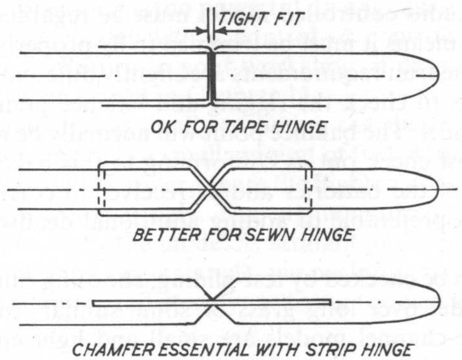


FIG.4.30

Table VII Safe maximum number of turns for escapement rubber motors

Size of rubber strip	Length of loop 10"	12"	14"	16"	18"	20"	22"	24"
$\frac{1}{8}''$	450	540	630	720	800	900	1000	1100
$\frac{3}{16}''$	350	420	490	560	630	700	770	840
$\frac{1}{4}''$	300	360	420	480	540	600	660	720

CHAPTER FIVE

FLYING R/C AIRCRAFT

A single-channel radio controlled model must be regarded partly as a free flight model. That means it must be trimmed to fly properly, like a free flight model, although the trim requirements are slightly different.

The first thing is to check the rigging and balance point of the finished, fully assembled model. The balance point will normally be noted on the plan, and the model must check out as conforming to this balance. If necessary, alter the position of the batteries and/or receiver to correct any deviation in balance. This is preferable to adding additional deadweight to produce balance.

Balance can then be checked by test-gliding, choosing calm conditions and launching the model over long grass or some similar 'soft' landing area. Virtually all single-channel models are small and light enough to be test-glided readily, when any adjustments necessary to initial trim should be made. The most important things are to ensure that the model glides straight, and with a reasonably fast and flat glide. Any marked tendency to nose up into a stall should be corrected by thin packing inserted under the trailing edge of the wing. Initial trim by packing is virtually the same as for free flight models, except that packing should be used to alter the rigging angle of the *wing*, not the tailplane. Also the initial glide trim aimed at should be faster and flatter than that of a free flight duration model (Fig. 5.1).

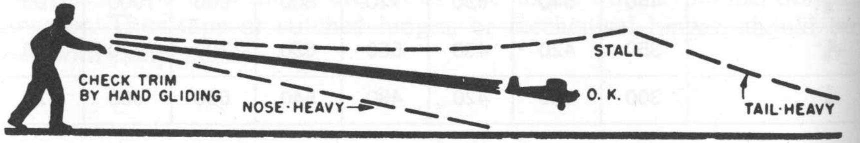


Fig. 5.1

The radio installation will have been checked out for working beforehand, in the workshop, and also tuned (if this is necessary). It will also have been fitted with fresh batteries (or batteries recharged) ready for flying. If the radio working has not been checked at range, then this will be necessary before considering making the first flight. Radio tuning, range checking, etc., are all described in Chapter 11.

A preflight check is still necessary to establish that everything is working properly. Start up the engine and adjust to normal running speed. Switch on the radio and check that all the control functions available work properly with the transmitter aerial fully extended. There is a possibility with some equipment that working with the transmitter close to the receiver will produce 'swamping' and cause an actuator to skip or misbehave. If this is suspected, move back a yard or so to overcome 'swamping', getting someone else to hold the model whilst the engine is running.

If the actuator still skips then the fault lies elsewhere – and is most likely to be caused by vibration, or from self-generated interference. In the case of an escapement it could be that the escapement motor has been wound up too much, or the rubber loop is too powerful. In any case it is inviting disaster to attempt to fly the model with a control or controls 'skipping' or not functioning properly. Return to your workshop, if necessary, to locate the fault and cure it – as described in Chapter 11.

First flights should aim at finally trimming out the model, keeping each flight short (e.g. by using only a small amount of fuel in the tank, or using the throttle control, if available, to terminate the flight in a 'powered glide'); and using the rudder control sparingly. The engine mounting may need adjustment of sidethrust to make the model fly straight under power, for example. Slight adjustment of wing rigging angle, via packing, may also be necessary to stop the model climbing too steeply, or flying too fast and level.

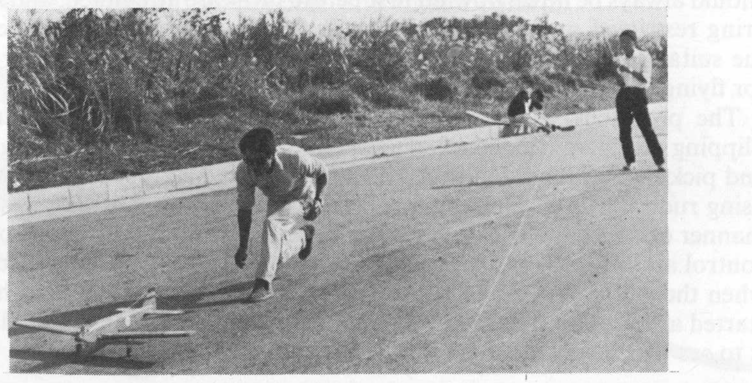


Plate 27 Small radio controlled aircraft are invariably hand launched – but you can try proper take-offs from smooth surfaces (preferably with the aid of a helper)

Final adjustments of trim can then be made by observing the response to rudder control, and subsequent recovery. A model which loses height excessively immediately on starting a turn may need a little more over-elevated trim. If the model zooms excessively on recovery from rudder, then this may need a little more under-elevated trim to cure. At this point, however *piloting technique* plays the most important part in the model's behaviour

Beginners will need to master the technique of flying with rudder control before they can hope to finally trim a model out for optimum performance.

Piloting technique necessary with rudder control is to apply a short rudder signal and release, repeating as necessary to maintain the required amount of turn. Ideally the least amount of rudder signal *duration* used the better, when the *spacing* between signals can be adjusted to control the rate of turn and thus the radius of turn. If any individual rudder signal is held on too long, the model will go into a diving turn and pick up speed. On release of signal the model will recover to level flight, but the excessive speed will cause it to zoom, and possibly even stall.

Thus rudder control should be thought of in terms of applying 'blipped' signals. In the case of a selective actuator this will mean 'single blips' for one rudder signal, and 'double blips' for the opposite rudder signal. It is all then a matter of timing, which can only be mastered by practice.

Over-control is worse than under-control. To reduce the possibility of over-control on training flights it is advisable to reduce the *rudder movement* available – e.g. see Chapter 3 and Fig. 3.1

The other important recommendation is that all training (or testing) flights should be made in calm air. Until the pilot is proficient at rudder control, he will invariably find that the model continually loses ground downwind and will be virtually impossible to direct back to the starting point if these is any appreciable drift. Even when reasonably skilled at rudder control flying, the golden rule remains that in windy weather the model should always be flown upwind first before turns are attempted, and manoeuvring restricted once the model has drifted back overhead. This can limit the suitability of many single-channel models, particularly smaller models, for flying in winds (Fig. 5.2).

The proficient pilot can make headway into wind, when required, by blipping alternate rudder, causing the model to 'fishtail', dropping its nose and picking up speed. In effect, the model is put into a shallow dive, simply using rudder action. Holding a substantially straight course upwind in this manner can be quite tricky, however. A slightly excessive amount of rudder control applied may easily produce a complete turn off the intended course, when the whole process of lining up and heading back into wind has to be started again. Also the farther the model gets downwind the more difficult it is to see which way it is flying.

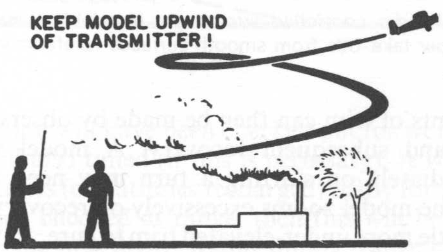


Fig. 5.2

Plate 28 Barnstormer, by D. Boddington. A really stable model for flying

Penetration for upwind flying, or even normal flying in windier weathe can be improved by increasing the amount of under-elevated trim, or t downthrust on the engine. Both adjustments will make the model fly faste At the same time they will make the model tend to dive more and pick u more speed in a turn.

Another point which should be emphasised when flying with rudd control is that all manoeuvres should be conducted with a good amount altitude in hand to start with. Considerable height can be lost in a turn, and lot of height if a turn is held on too long. Considerably greater height is lo in many other manoeuvres possible with rudder control.

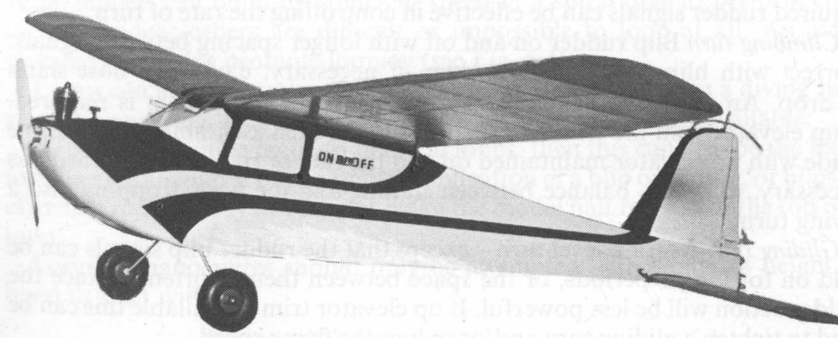


Plate 29 Half Tone, by D. Platt. A lightweight flier for single channel RC

This rule of having 'height in hand' also applies when a model is bein landed at the end of the flight. The model should be lined up in a straigh approach, headed upwind, whilst still at a reasonable height (more tha would normally be lost in a complete turn, for example). The model shou then be left to land itself. Last minute corrections by using rudder close to th ground can lead to disaster, and the model stalling in, or making a diving tur

into the ground. Again the expert pilot can disprove the rule by 'fishtailing' a model in at a low altitude to produce a 'spot' landing – but even he will leave the controls untouched for the last part of the landing (Fig. 5.3).

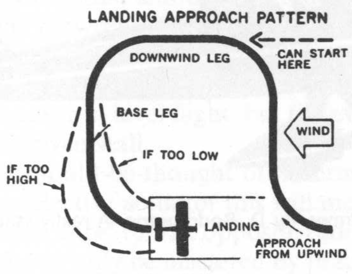


Fig. 5.3

Basic manoeuvres

The basic manoeuvres possible with rudder-only control are as listed under, with notes on piloting technique, etc.

'Level' turns Blip rudder on and off, adjusting the rate of blipping and the spacing between blips to maintain the required degree of turn. Turn performance with almost any model can be adjusted to an optimum by slight changes in trim; but piloting technique is more important. In some cases momentarily blipped signals of *opposite* rudder interposed between the required rudder signals can be effective in controlling the rate of turn.

Climbing turn Blip rudder on and off with longer spacing between signals. Correct with blips of opposite rudder, if necessary, e.g. if the nose starts to drop. An over-elevated rather than an under-elevated trim is required. If up elevator trim movement is also available, then a climbing turn can be made with up elevator maintained on and the rate of rudder turn 'timed', as necessary, to hold a balance between stalling and the nose dropping into a diving turn.

Gliding turn As for a level turn – except that the rudder blip signals can be held on for longer periods, or the space between them shortened, since the rudder action will be less powerful. If up elevator trim is available this can be used to tighten a gliding turn and/or reduce the flying speed.

Diving turn The appropriate rudder signal is held on. It should be released completely well before the model has completed a full turn, however, otherwise a spiral dive will result.

Spiral dive Rudder held on – see above. This manoeuvre should only be started from a good height – at least 500 feet for safety – as the height lost in several turns of a spiral dive can be considerable (Fig. 5.4).

Recovery from diving turn or spiral dive Neutralise rudder to initiate recovery. Because considerable excess flying speed will have been built up it will be necessary to apply opposite rudder, or better still alternate rudder to

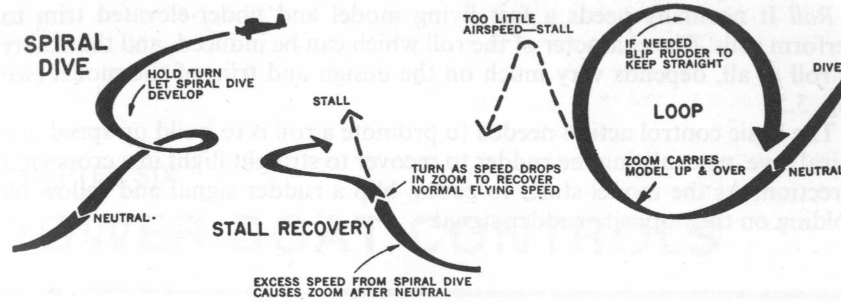


Fig. 5.4

'fishtail' the model once the model has resumed a straight flight path. If no it will zoom into a stall.

Shallow dive Apply blipped signals of alternate rudder to 'fishtail' th model. Considerable practice is likely to be necessary to be able to maintai a straight course with this manoeuvre. If throttle control is available, this easiest to perform with 'slow' throttle. However, maximum penetration wi be obtained with 'fast' throttle.

Stall turn Build up speed in a complete diving turn, starting and recoverin heading into wind. As the model zooms into a stall, apply a blip of rudder a the top of the stall (see Fig. 5.4).

Loop Build up speed with two or three turns of a spiral dive. Recove heading into wind. If the model has sufficient speed it should complete a loop Some models can build up sufficient speed in a spiral dive to perform con secutive loops; others are difficult or impossible to loop at all. An ove elevated trim helps promote looping (see Fig. 5.4).

Loops can also be produced directly by building up speed in a diving tur and then applying 'kick elevator', or 'up' elevator trim, when available.

If the model can be made to perform loops, then this can also be the bas for other manoeuvres. For example, application of a blip or rudder, or blips o alternate rudder, may or may not make the model half roll out of the top of loop.

Looping manoeuvres should only be attempted with plenty of height i hand to start with.

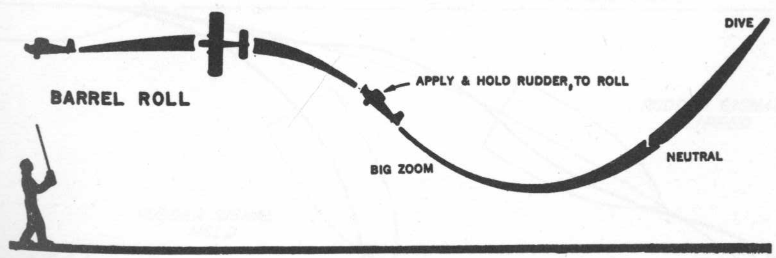


Fig. 5.5

Roll It normally needs a fast flying model and under-elevated trim to perform rolls. The character of the roll which can be induced, and the ability to roll at all, depends very much on the design and trim of the model (see Fig. 5.5).

The basic control action needed to promote a roll is to build up speed in a spiral dive, neutralising the rudder to recover to straight flight in a crosswind direction. As the model starts to zoom, blip a rudder signal and follow by holding on the opposite rudder signal.

CHAPTER SIX

POWER BOAT CONTROLS

The one essential control in the case of a model boat is *rudder*. This is readi provided by a simple single-channel system. However, the fact that it has work in a fairly dense fluid (i.e. water) means that it requires a fair amount driving power. This virtually rules out the use of escapement type actuato for rudder control, except possibly on very small and slow-moving electr powered models. Even then, the fact that an escapement needs a rubb motor to drive it complicates the installation. Thus motorised actuators ca be regarded as the general rule for operating boat rudders.

A motorised actuator should have sufficient power to operate virtual any type of size of rudder likely to be required on a model boat, althoug 'balanced' rudder designs are usually employed on power boats. These ma be popularly called R/C rudders, and should certainly be used on all hig speed boats.

Very satisfactory boat operation can be obtained with rudder-only contro especially using a selective actuator. The rudder control available is eithe full 'on' or 'off' (neutral). This can be used in two ways. The rudder movemen can be selected (or, in practice, adjusted) to give the tightest turn likely to b needed (or the tightest turn which is safe for the model). Signalling rudde and holding the signal on, will then give a tight turn in the direction com manded. Shallower turns are then obtained by blipping the same rudd signal on and off. This will open up the turn by interposing intervals 'neutral rudder' between 'rudder on' – producing what can be described as weaving turn – Fig. 6.1.

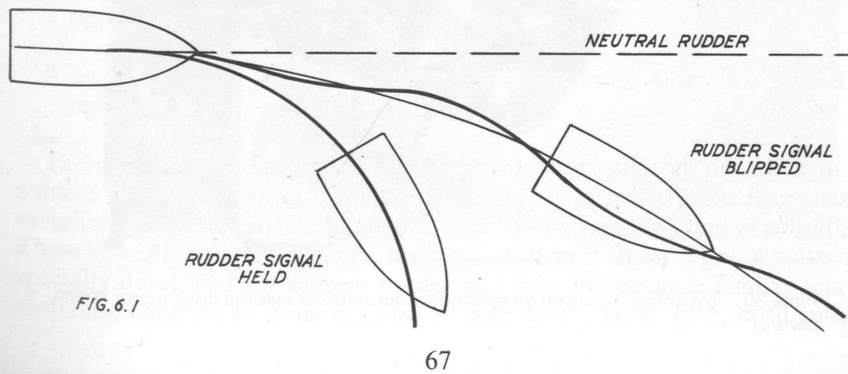


FIG. 6.1

The principle is exactly the same as for aircraft rudder operation, except that the 'timing' of blipped signals is far less critical. Also a boat does not have such a violent reaction to rudder control as an aircraft and moves more slowly in any case. It is much *easier* to control than an aircraft – and much safer.

It is certainly worthwhile considering extending the functional control services available to speed control as well. Model boats powered by i/c engines (diesels or glow motors) usually run at high speeds and rudder-only is not sufficient for complete control. The logical extension of control is thus to use a second actuator to operate throttle changeover, operated by a 'quick-blip' transmitter signal.

The main actuator and secondary actuator are thus chosen accordingly – the former being a S/N 2P selective type, with 'quick-blip' switching contacts. The secondary actuator can be either a 2P or 3P progressive type – see Chapter 2. The diesel or glow motor used must, or course, be fitted with a throttle. The extra weight of the second actuator, and the space needed to accommodate it, will not be significant. There is almost certain to be room, even in the smallest engine-powered model boat hull, to accommodate rudder plus throttle control. The receiver can be either a relay type, or a relayless type connected to a separate relay for switching the main actuator circuit.

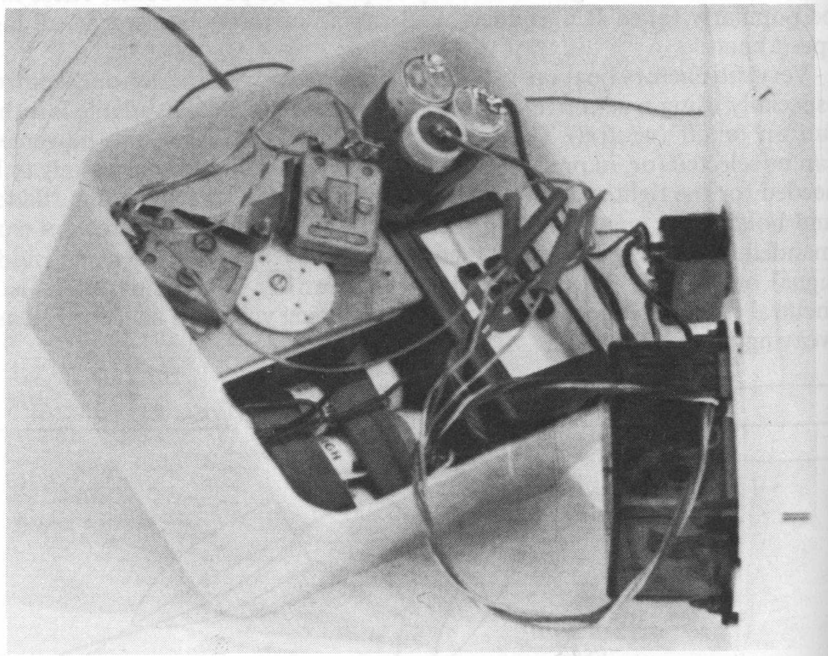


Plate 30 Switches mounted on secondary actuator for electric drive motor speed control

In the case of an electric powered boat, 'speed' control can be obtained simple switching, again using a secondary actuator operated by a 'quic blip' signal. The output movement of this actuator is then used to opera switching contacts in the electric drive motor circuit. A 3-position outp movement gives the best switching possibilities and so the secondary actuat chosen should preferably be of the 3P type.

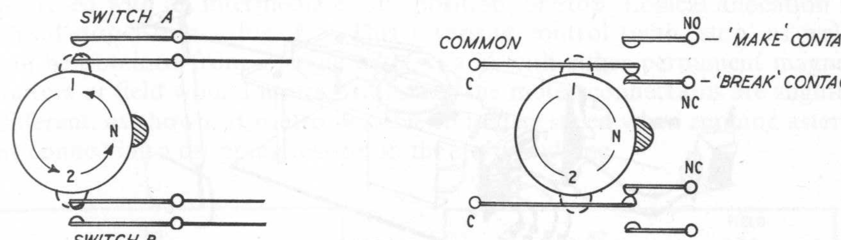


FIG. 6.2

Fig. 6.2 shows a typical switching system applied to a 3P actuator. position 1, the actuator movement changes over the contacts on switch When the actuator returns to neutral (N) the contacts on both switch A a switch B are in their NO (normally open) positions, i.e. neither switch operated. In position 2, the contacts on switch B are changed over.

This diagram also shows two forms of switches – one with just two contac (left), and the other with three contacts worked on a changeover basis. T former provides plain on-off switching for a circuit, and are adequate f many simple switching circuits. The other type of switch with three contac provides greater versatility of switching arrangements and is generally to preferred. The separate contacts are referred to be their normal (i.e. u operated) position, viz:

a common contact (C) (corresponding to the armature connection on relay)

A normally closed (NC) contact, which is 'broken' when the switch operated

A normally open (NO) contact, which is 'made' when the switch operated

The switches can be of simple leaf spring type, suitably mounted to worked by the actuator movement; or preferably microswitches. Proprieta switching units are also available to fit directly onto certain types of actuator These virtually convert the actuator into a *switcher*. Other types of actuato specially developed for marine model use, may incorporate similar sets switching contacts in a main actuator unit. In the latter case, both rudd

movement and switching contacts for electric drive motor control are provided by a single actuator – e.g. see Fig. 6.3.

If only a *single* switch is used then there are three main control possibilities:

(i) stop-go
(ii) ahead fast – ahead slow
(iii) ahead-astern

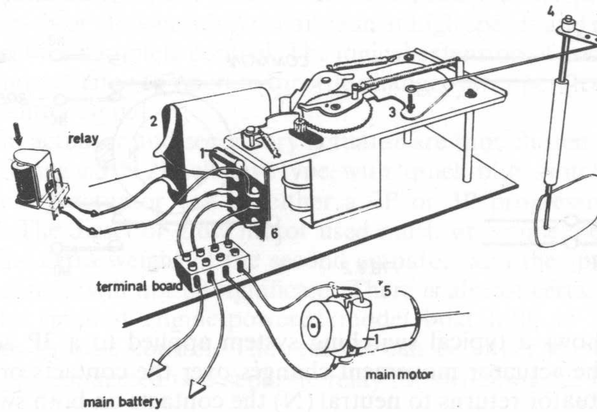


Fig. 6.3 'Kinematic' marine actuator. (1) capacitor (for suppression), (2) actuator battery, (3) 'Kinematic', (4) rudder linkage, (5) drive motor, (6) drive motor switching connections

The respective circuits are shown in Fig. 6.4. 'Stop-go' switching is readily understood since the switch is merely operated as an 'off-on' switch for the drive motor circuit, the NC contact of the switch not being connected to anything. The 'fast-slow' circuit is almost as simple, except that both switch contacts complete the drive motor circuit, but one of these circuits includes a resistor in the circuit. This resistor is effective in dropping the voltage, resulting in the drive motor running at reduced speed. A suitable value of resistor for small electric motors is 5 to 10 ohms. It must have a power rating suitable for the wattage it is likely to have to withstand (watts = voltage times amps).

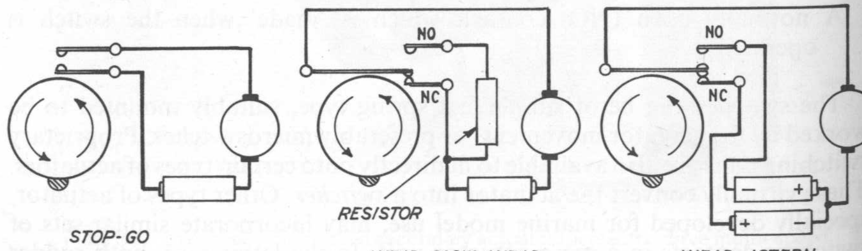


FIG. 6.4

The third circuit is rather less useful, although it does have applications. It requires the use of two batteries. The switching contacts then chang over the drive motor supply from one battery to the other, reversing th polarity and thus giving ahead-astern switching with permanent magne motors. Since less speed is usually required astern, the second battery ca be of lower voltage to give 'ahead-slow astern'.

With *two* switches operated by a 3P actuator, two separate controls ar provided with an intermediate 'off' position, or stop. Logical allocation i ahead-stop-astern – Fig. 6.5. This reversing control (with 'stop' as well can be obtained from a single battery, and with either permanent magne motors or field wound motors, although the motor connections are slightl different, as shown. It is also possible to reduce speed when running astern by connecting a dropping resistor in the stern feed line.

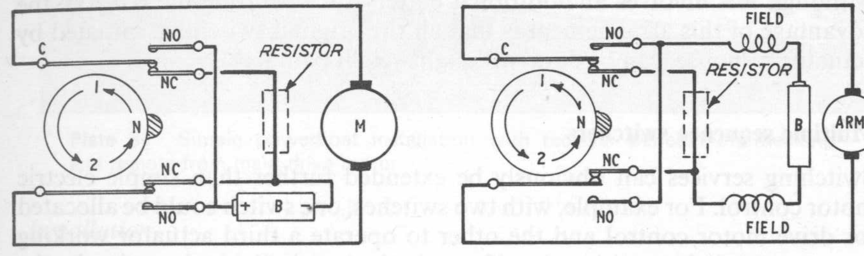


FIG. 6.5

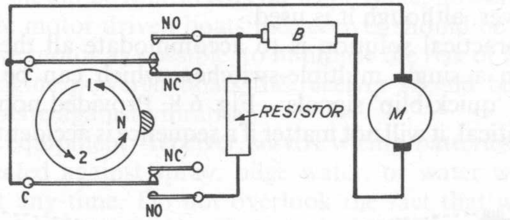


FIG. 6.6

Fig. 6.6 shows another useful switching circuit, applied to permaner magnet drive motors. It gives 'ahead-stop-slow ahead', again using a droppin resistor in the 'slow' circuit. There are also numerous other possibilitie which can be worked out, but the above are the main *simple* circuits used fo electric drive motor control with single-channel systems.

About the only limitation with such systems is that it is essential that th switching contacts used be capable of carrying the full motor circuit curren If the drive motor is a large, powerful type drawing high currents it may b necessary to use the switching contacts to operate a slave relay with contact having a suitable current rating – Fig. 6.7. The original switching contact

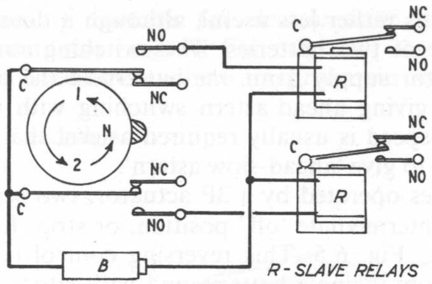


FIG. 6.7

then only have to pass enough current to energise the relay, and can be of lightweight type. The actual drive motor switching is then performed by the relay contacts, wired as per any of the switching circuits described above. Although this involves an additional battery for operating the relay(s), the advantage of this arrangement is that all the original switching, initiated by actuator response, can be done with lightweight contacts.

Multiple sequence switchers

Switching services can obviously be extended further than simple electric motor control. For example, with two switches, one switch could be allocated for drive motor control and the other to operate a third actuator working two more switches, and so on if required. Any individual service in the switching chain can then be selected by giving the appropriate number of 'quick-blip' signals. This method of extension of services tends to be cumbersome, however, although it is used.

A more practical solution is to accommodate all the secondary service switching on a single multiple-switcher, which can be stepped round in sequence by 'quick-blip' signals – Fig. 6.8. Provided none of the secondary services is critical, it will not matter if a sequence is accidentally lost, or wrongly signalled.

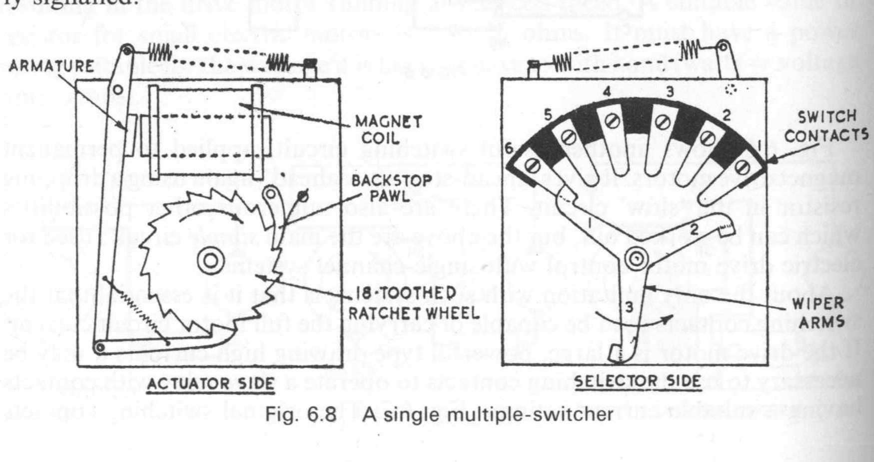


Fig. 6.8 A single multiple-switcher

The type of switcher required is one with a rotary motion which is trippe one step by each 'quick-blip' signal. Unfortunately no rotary switchers suitable type appear to be available commercially and so such units need be home made.

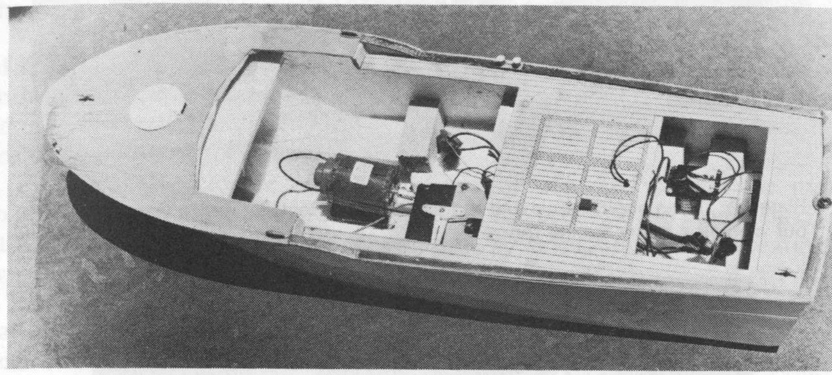


Plate 31 Simple powerboat installation with receiver beneath afterdecking and remote from main drive motor

Installation

It is difficult to generalise on the subject of installation since this can va widely, depending on the type and size of model involved. The followin recommendations should be followed as far as possible, however.

(i) With electric motor driven boats the receiver should be placed as f away from the drive motor as possible, to minimise the risk of interference

(ii) With i/c engine powered boats the receiver should be wrapped foam rubber to isolate against vibration.

(iii) All electric equipment – receiver, servos, wiring, batteries and switch – should be protected against spray, bilge water, or water which may b shipped aboard at any time. Do not overlook the fact that water is ofte accidentally shipped when launching a model boat, or removing it from th water.

Basic installation requirements otherwise follow on similar lines to th described for aircraft (Chapter 4), although fore and aft weight distributio is seldom a critical factor (except in the case of heavy batteries for an electr drive motor). All wiring runs should be cabled and supported well above th bilges; and where hatches are incorporated in the superstructure, etc., fo access, these must be watertight when fitted.

The question of 'waterproofing' is one which can be debated at lengt Some marine type actuators are specified as 'waterproof', which implie that they can withstand damp conditions. Aircraft type actuators, receiver relays, switches and batteries are not waterproof and cannot be 'waterproofe except by enclosure.

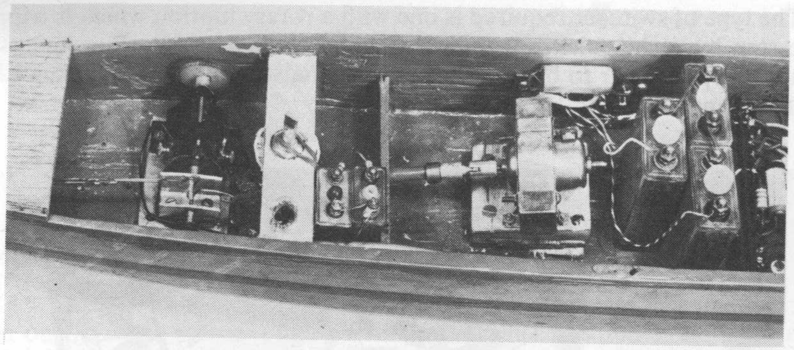
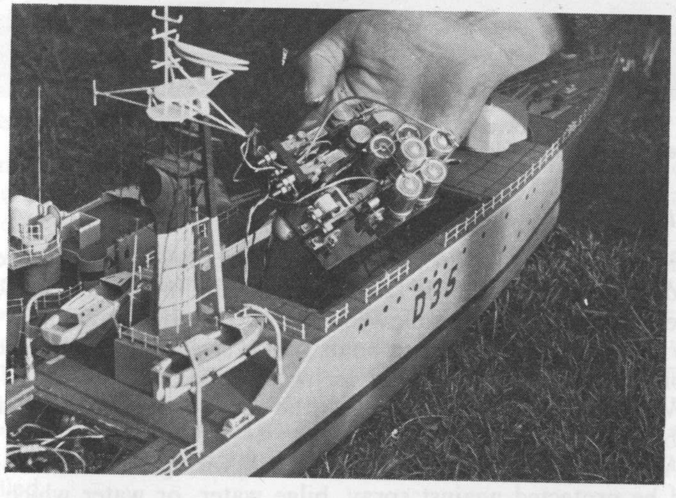


Plate 32 Main engine drive and rudder actuator. Receiver just in view on right, but would be better further forward



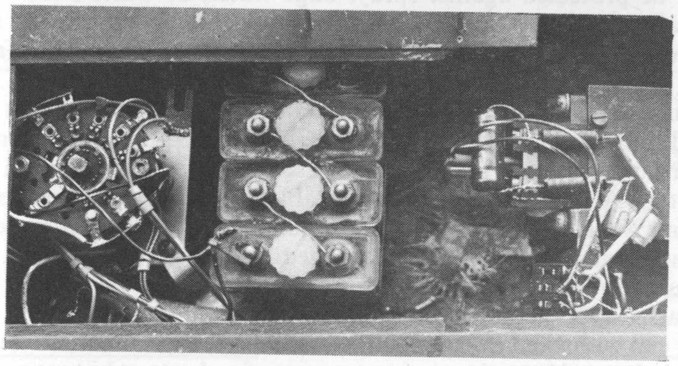


Plate 33 Many scale boats lend themselves to 'multiple' services operated via home-made switchers and actuators

Two alternative methods of 'waterproofing' in such cases are to enclo receiver, batteries and switch in a suitable rigid plastic box with cover (e.g. sandwich box); or wrap these units in a polythene bag. In the former cas wiring can be taken through holes in the side of the box, 'sealed' with rubb grommets. Alternatively, wiring can be terminated in sockets in the side the box, into which external wiring connections can be plugged.

With polythene bag enclosure, all wiring can be taken out through the nec of the back, which can then be 'sealed' with a rubber band. For complet sealing it would also be necessary to pack the neck with grease or wax. Th aerial wire should emerge from a separate point, which can present a furthe sealing problem.

Fully sealed enclosure, whether by box or bag, can protect the mo expensive – and more vulnerable – items in the event of the model sinkin It is difficult to achieve 100 per cent sealing, however, and so such treatme will not necessarily provide complete protection.

There is also an objection to complete sealing in that it can lead to conder sation occurring *inside* the enclosure. This is difficult to avoid in a rig sealed enclosure, but can be offset by including some sacs of silica ge dessicant in the enclosure to absorb any internal moisture present. In th case of bag enclosure, the possibility of condensation can be minimised b sucking and/or pressing as much air as possible out of the bag before final sealing. Again a sac of dessicant can be included as a further precaution.

Aerials

Because of the relatively short operating range required with model boats, short receiver aerial length can be used – 18 to 20 inches being a typical figur This is normally in the form of a vertical 'whip', either 18 or 20 gauge pian wire, or a short telescopic aerial. The most important thing is to ensure good electrical connection between the fitted aerial and the receiver aeri wire, preferably with a soldered joint rather than a plug and socket typ connection.

Satisfactory performance can sometimes be obtained using the ordinar receiver aerial wire carried around the hull of the boat under the deck.

Suppression

Suppression can be an important feature of marine model radio installation particularly where the drive motor is an electrical motor and switchin contacts are used for motor control. Suppression is applied to quench an sparks generated, which are virtually a form of radio signal which can readil be picked up by most receivers as spurious signals.

Various methods of suppressing an electric motor are shown in Fig. 6.9 The simplest method is to connect a capacitor directly across the brushes A suitable value is usually ·01 to ·05 microfarads. This may only provid partial suppression, in which case two capacitors can be tried, one connecte

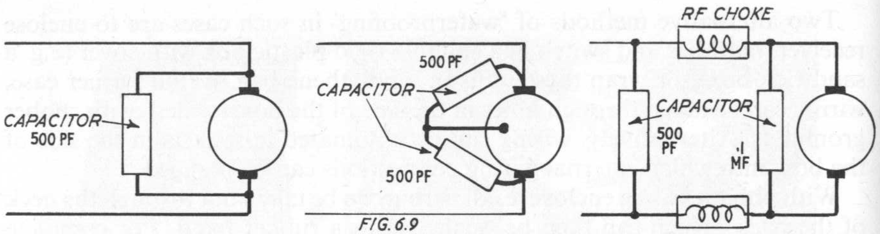


FIG. 6.9

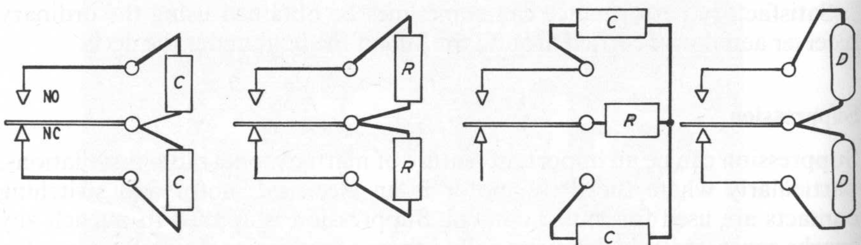
to each brush contact and with the other ends connected to the motor casing to 'earth'. This will only be effective where the motor casing is metallic.

If more suppression is required, then chokes can be fitted in each motor lead, typical values being 70 to 100 microhenries, together with a further 500 picofarad capacitor across the supply end of the chokes. One of the most effective methods of reducing interference from an inherently 'noisy' motor, however, is to place as much distance as possible between the motor and receiver (and receiver aerial).

No treatment is usually required for actuator motors since suppression components are built into the motor circuits.

Methods of suppressing contacts are shown in Fig. 6.10. Again the simple treatment is to connect a capacitor directly across each contact; or a capacitor in series with a resistor. Either method can usually provide complete suppression, using capacitor values of ·01 microfarad (and resistor values of 10 ohms, if used in series with a capacitor).

Coils can also be a source of 'noise' when included in a switching circuit. When the circuit is broken the inductance of the coil can produce a surge of high voltage, increasing the tendency for the contacts to spark. Normally this is catered for by applying suppression to the contacts. The coil in the circuit can also be suppressed, if thought necessary, by connecting a diode directly across it, observing the correct polarity for the diode.



C- O1MF CAPACITOR R - 50 OHM RESISTOR D-DIODE

FIG. 6.10

CHAPTER SEVEN

YACHT CONTROLS

Satisfactory radio control of a model yacht can be obtained with just rudd
control, although this basically limits manoeuvring to simple tacking a
occasional course correction, as necessary. Thus with rudder control
model yacht could be trimmed for a reach and sailed backwards and forwar
across a pond more or less indefinitely.

Rudder control can be used with self-adjusting sails, to provide rath
greater opportunity for course steering with the sails pulling properly. T
basis of a self-adjusting sail system is to connect the forward end of the ma
sheet to the jib sheet, either directly or via a pulley, as shown in Fig. 7
Thus in sailing, pressure on the mainsail causes the main boom to move o
and at the same time hauls in the jib. This will cause the yacht to veer
until pressure on the mainsail slackens. The scope of such self-adjusting s
setting is distinctly limited, however.

For full control of a model yacht, the commands available must extend
sheet winching. This enables the sails to be set for any course it is desired
steer. Once the yacht has been set on this course, with the sails properly s
it should then be capable of maintaining that course with minimum use
rudder control.

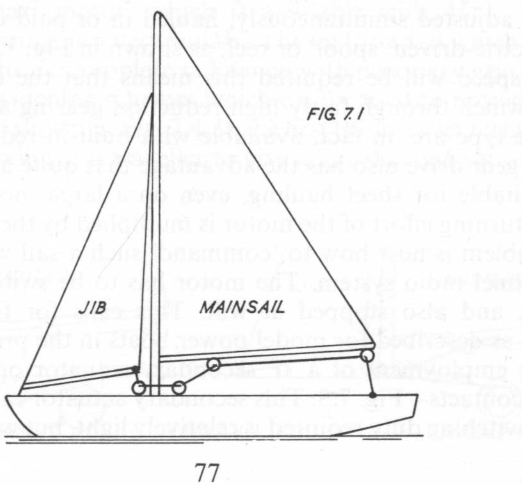


FIG. 7.1

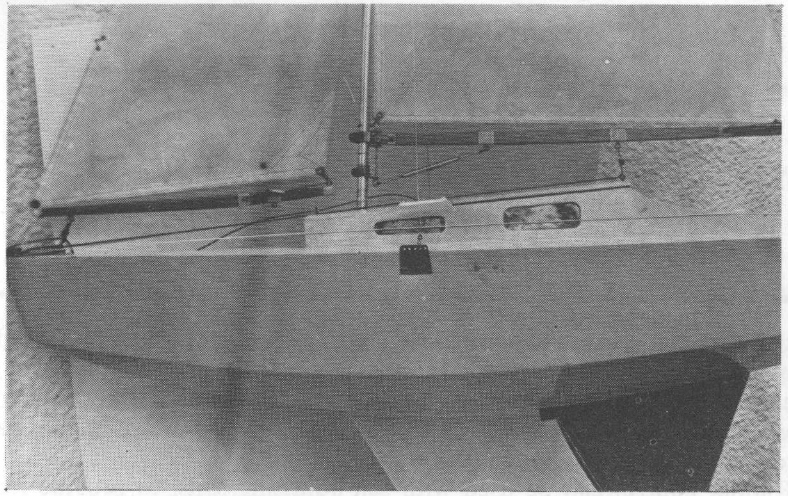


Plate 34 Sail winch sheeting on model yacht controls

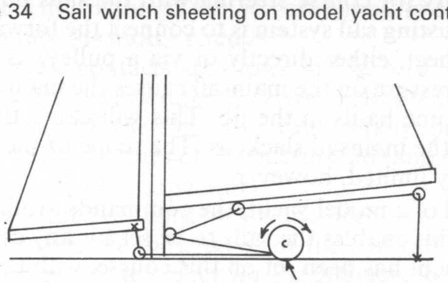


FIG. 7.2

Mechanically, sail winching is quite straightforward. Both jib and main sheets are adjusted simultaneously, hauled in or paid out by rotation of a simple electric-driven 'spool' or reel, as shown in Fig. 7.2. Since only a slow winching speed will be required this means that the electric motor must drive the winch through fairly high reduction gearing and compact motors of suitable type are, in fact, available with built-in reduction gearing. The reduction gear drive also has the advantage that quite a small size of motor will be suitable for sheet hauling, even on a large model yacht, since the torque or turning effort of the motor is multiplied by the reduction gearing.

The problem is now how to 'command' such a sail winch simply from a single-channel radio system. The motor has to be switched to run in both directions, and also stopped at will. This calls for forward-stop-reverse switching, as described for model power boats in the previous chapter. This means the employment of a 3P secondary actuator operating two sets of switching contacts – Fig. 7.3. This secondary actuator can be an escapement, since the switching duty required is relatively light, but would preferably be a

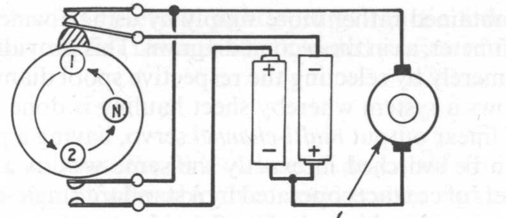


FIG. 7.3

motorised actuator. An escapement would need the additional complicatio
of a rubber motor which would have to be made accessible for winding, whic
is a major point against it.

Operating the sail winch 'command' by 'quick-blip' signal then leave rudder control freely available via a selective type S/N 2P main (motorised actuator. The only real limitation of the system is that it will not be obviou which way the sails will be winched on giving a 'quick-blip' signal – startin from a 'stop' position the next switching movement of the secondary actuato can be *forward* or *reverse* switching. It will be easy to observe what is happen ing, however, and correct if necessary by giving two 'quick-blips' in succes sion to reverse the motion of the winch (i.e. to switch back through stop t the opposite switching position). Even this need not apply if the operator ca remember the *last* signal.

Once the sail winch has been switched into motion it will continue runnin in that direction until stopped by another 'quick-blip' signal. This is where high reduction gearing is helpful. The slower the winch speed the mor easily the required stopping position can be estimated, and the easier it is t make fine re-adjustments. If the winch speed is too high, it may be impossibl to adjust sail setting accurately.

Winch reduction gearing should be of the order of 200:1, applied to a electric motor with a normal spindle speed of the order of 5,000 rpm. Th Graupner 'Micromax' motor, which is available with 41:1, 141:1 an 485:1 reduction gearing, is a very suitable choice for a sail winch drive. Th same firm also produce a complete sail winch with necessary gearing.

Two alternative winching schemes which can be used to provide differen tial sheet hauling are shown in Fig. 7.4. In the first the jib sheet terminates on separate block, working as a traveller to give a 2:1 sheeting ratio. The sam

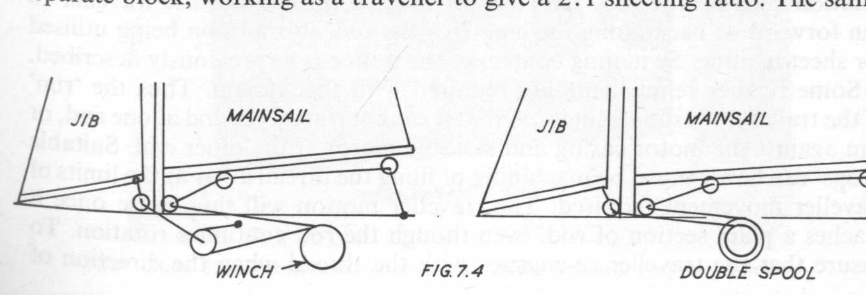


FIG. 7.4

effect can be obtained rather more simply by using a winch with two spools of different diameter, as in the second diagram. This provides for any differential required, merely by selecting the respective spool diameters accordingly.

Fig. 7.5 shows a system whereby sheet hauling is done by a pivoted lever operated by a linear output *multi-channel* servo, having a progressive action. This servo can be switched in exactly the same way as a sail winch motor through two sets of contacts operated by a standard single-channel secondary actuator. The circuit is shown in Fig. 7.6.

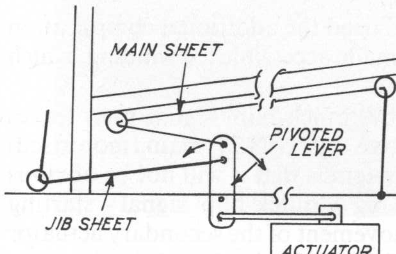


FIG. 7.5

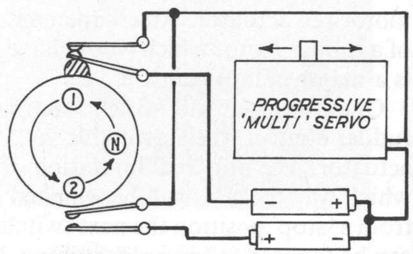


FIG. 7.6

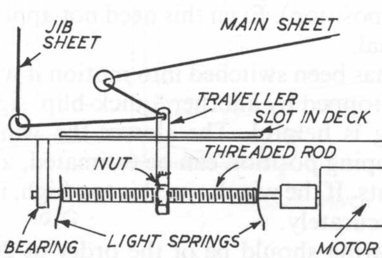


FIG. 7.7

Another system which avoids the use of a winch drum (and the possibility of sheets fouling on the reel), is shown in Fig. 7.7. The output of an electric motor is connected to a threaded rod (e.g. a length of 4BS brass studding), suitably supported in bearings. A threaded traveller constrained against rotation runs on the rod. Rotation of the rod thus causes the traveller to run forward or back along the length of the rod, this motion being utilised for sheet hauling. Switching control of the motor is as previously described.

Some further refinements are required with this system. Thus the 'run' of the traveller must be limited, so that it cannot run off the rod at one end, or jam against the motor casing and stall the motor at the other end. Suitable 'stops' can be arranged by machining or filing the thread away at the limits of traveller movement required. The traveller motion will thus cease once it reaches a plain section of rod, even though the rod continues rotation. To ensure that the traveller re-engages with the thread when the direction of

rotation of the thread is reversed, light springs can be fitted at the li positions to bias the traveller towards the threaded section of the rod.

Radio installation

Radio installation follows the lines already described for power bo (Chapter 6). It is generally advisable to enclose receiver and batteries in o sealed box (or bag), and the rudder actuator in a second enclosure, althou this may not be necessary with a 'marine' type (waterproof) actuator. wiring should be cabled up and supported under the deck line, well clear the bottom of the hull. The aerial wire can be brought up through a h in the deck, sealed with a small rubber grommet, and then taken up the ma

The deck hatch (or removable cabin structure) must provide a good wat tight fit when in position. Yachts are more susceptible to taking water o their decks than power boats and every effort should be made to maintai 'dry' hull. For this same reason, always consider bilge water a possibil in a model yacht hull, and thus locate all electrical gear as high as possi in the hull and towards the centre, not attached to the hull side.

Typical practical installations are shown in Plates 35 and 36.

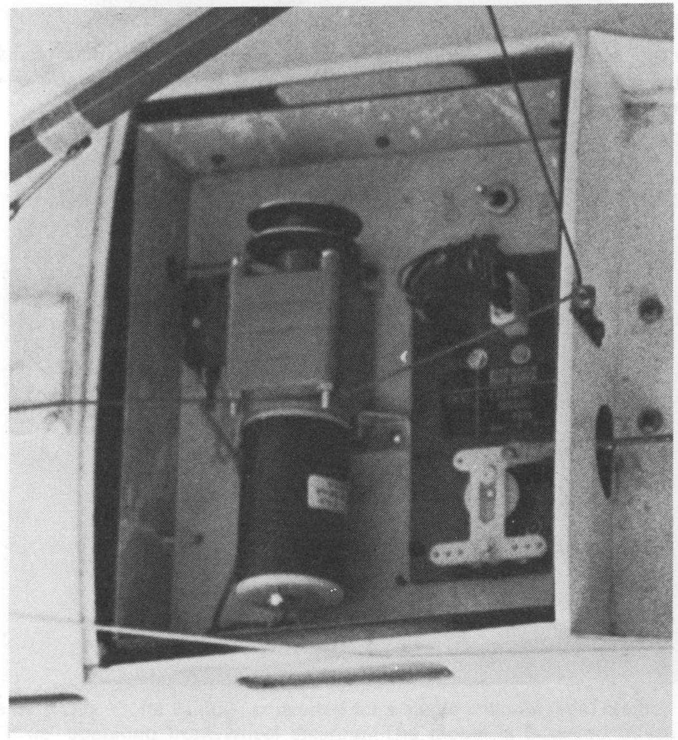


Plate 35 Yacht controls showing rudder actuator and sail winch

Plate 36 Model yacht installation showing receiver and rudder actuator mounted in a waterproof box. Linkage to rudder is external. Note also on-off switch in top of box

CHAPTER EIGHT

RADIO CONTROLLED CARS

Single-channel radio has a rather more limited application for the contro of cars and ground vehicles, compared with the scope offered by mod aircraft and boats. However, there is much that can be done, particular with electric powered cars where the slow running speed makes control actio and response time far from critical.

The basic requirements for functional control of a model vehicle are:

(i) steering.

(ii) drive motor control.

Both can be made available with simple single-channel radio with an electr drive motor, using a motorised actuator for steering, with a switching facilit to operate a secondary actuator for drive motor switching. If space is limite – as it usually is on smaller size model cars – then a single (main) actuato

Plate 37 Cox 'Dune Buggy', converted for a single channel radio control, with OS 'Pixie' operating front-wheel steering. The model is powered by an 049 glow-plug motor.

can be used which incorporates built-in switching facilities for drive motor switching. Unfortunately relatively few of this latter type of actuator are now available commercially. But the ingenious modeller can adapt a standard actuator, or make his own special actuator, to meet the requirements of 'single actuator' working where space is limited.

Steering

A motorised actuator must be used for steering control as an escapement will not have enough power for the purpose. (There are the exceptions to prove the rule, and the clockwork escapement has also proved a practical solution. Unfortunately the latter type is no longer made.) A conventional S/N 2P actuator will then give right or left steering, with automatic self-centring for straight running. A selective type actuator is to be preferred.

The scope provided by 'bang-bang' steering is adequate, and fairly readily controllable (with practice) provided the drive motor is geared down sufficiently to produce relatively low speed running. It is not possible to vary the degree of turn by 'on-off' signalling, as with aircraft or boats, since a wheeled vehicle will respond immediately and continually to steering – Fig. 8.1.

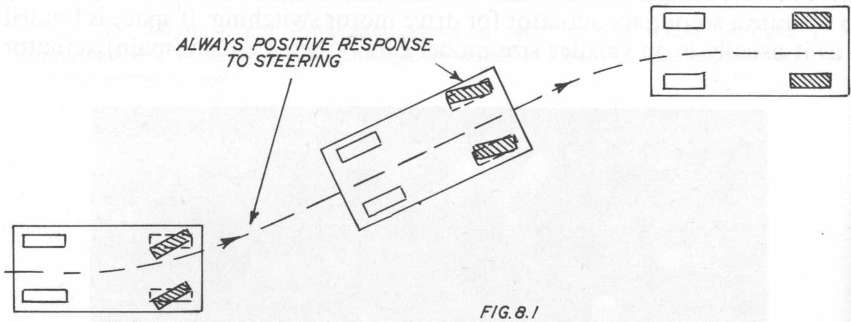


FIG. 8.1

Progressive steering

A simple progressive type of steering is shown in Fig. 8.2, using a small electric motor in place of an actuator. This motor is switched on and off by the receiver relay (or by a slave relay in the case of a relayless receiver). Substantial reduction gearing is used and when signalled on the motor drives the steering continuously from full lock to one side, to full lock the other, and so on. On release of signal the motor stops, holding the steering at that particular position.

With this form of steering control it is possible to set any degree of turn required, and re-adjust steering to any new position required by suitable timing of the next 'on' signal – i.e. holding the signal on for sufficient time for the motor to drive the steering to the required position.

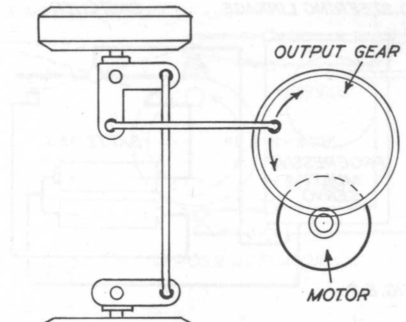


FIG. 8.2

In practice this system has a number of limitations. The main one is tha to change from, a gentle turn in one direction to a turn in the opposit direction the steering may have first to move through full lock position in th first direction and then back again. To *repeat* a turn in the same directio after the turn has been straightened out it will *always* be necessary to stee right through opposite lock. Also to straighten out after a gentle turn, i will be necessary to go through full lock first.

Proportional steering

Proportional steering is obviously to be preferred. This can be provided by simple pulse proportional system, provided the steering load is not too heav for the proportional actuator to handle. Again the actuator can be base on an electric motor, although magnetic actuators have also been use successfully on light models (e.g. the American Adams magnetic actuator)

With a pulse proportional system a high pulse rate is required to preven the vehicle responding to individual steering pulses. Smooth steering ca usually be obtained with pulse rates of 10 pulses per second, or higher.

Multi-servo steering

This is another form of *progressive* steering, but using a progressive *multi channel* actuator switched by a single-channel actuator (and thus worke by a simple single-channel radio link). The single-channel actuator ca be a S/N 2P type or a 3P progressive type. In either case its movement is use purely to operate switches controlling the multi servo circuit – Fig. 8.3. A S/N single-channel actuator is to be preferred since this can be a selectiv type, and avoid signalling through a sequence to reverse the steering direc tion. Neither will provide self-centring of steering, however. The steering i inched in either direction to an extent dependent on the duration of holdin on the signal, and stops in this position as soon as the signal is released.

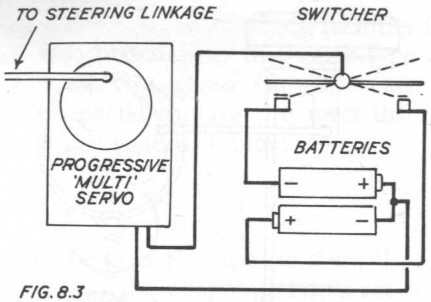


FIG. 8.3

The advantage over simple progressive steering previously described is that the steering direction can immediately be reversed, since the multi servo can be switched directly to drive in the direction required. The main disadvantage of the system is that it requires *two* actuators to control one function (steering) – one a single-channel actuator to utilise the single-channel signal available, and a multi servo to convert the switching commands derived into selective two-way steering.

Proportional steering

Proportional steering is obviously to be preferred. But the only simple and direct way to provide this is via a true single-channel (1-function) proportional transmitter-receiver-proportional actuator combination. The cost will be higher than that of a simple single-channel control system, but if the outfit also provides '+1' facilities for a separate signal, this can be used for drive motor switching control. This combination – proportional steering and drive motor switching – will give complete functional control of a wheeled vehicle.

Drive motor control

This is readily provided by conventional switching circuits operated by a 'quick-blip' facility on the main (steering) actuator with straightforward single-channel systems. This switching facility is used to control a 2P or 3P progressive action secondary actuator, the movement of this actuator operating one or two sets of switching contacts, respectively. A 2P actuator can then give 'stop-start' (off-on) switching of the electric drive motor. A 3P actuator can provide switching for 'forward-stop-reverse', which is the most useful coverage – Fig. 8.4. Running speed in reverse can also be reduced, if necessary, by including a dropping resistor in the reverse drive circuit. Other possible switching combinations can follow those used for electric powered boats – see Chapter 6.

The 'stop' switching facility is a particularly useful one, and can be regarded as essential for good control. It combines the function of both braking and stop.

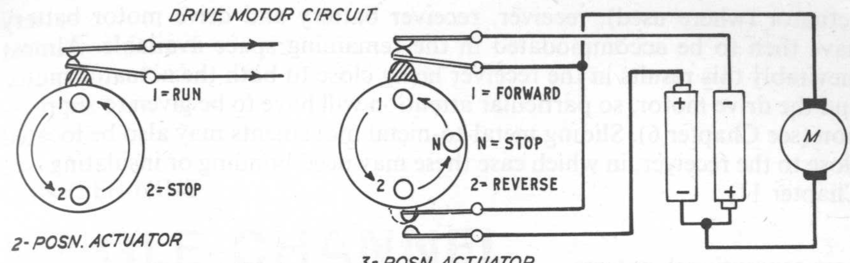


FIG. 8.4

Theoretically, at least, it is easy to provide speed control of an i/c engin used to drive a model car, on a conventional changeover basis (i.e. slow-fas slow, etc.) operated by the secondary actuator, as with aircraft and boat This would not be a practical scheme, however, except with true propor tional steering. This is because the speed at which engine-powered mode cars run is too high for positive – and safe – control by 'bang-bang' o progressive steering.

Extending the services

The use of a multiple-position switcher instead of a conventional secondar actuator allows the services to be extended in a similar manner to tha described for model boats. Ideally this should not interfere with the read signalling of drive motor switching, for this must be regarded as a primar (functional) control.

This is against incorporating drive motor switching in a sequence involvin secondary services, such as lights and horn. The whole sequence has to b switched through to get back to drive motor switching positions.

Preferably, therefore, where additional services are to be included thes should be 'isolated' on a separate switcher. This would favour the use of a S/N 3P main actuator, which also provides 'quick-blip' switching. Th 'quick-blip' facility can then be used to operate drive motor switchin through a second actuator; and the 'third' position on the main actuator less easy to signal – allocated to trip a third actuator or switcher which con trols the ancillary services.

Space restrictions may, however, preclude the use of additional actuator switches, in which case all the switching facilities will have to be provide by the secondary actuator, or even a special design of main actuator.

The above descriptions cover more or less conventional approach to th control of model cars via single-channel radio – with plenty of scope fo ingenuity in extending switching services. The main problem, especiall with smaller models, is getting all the necessary 'works' inside a scale bod shape.

The usual layout is to locate the main (steering) actuator as close to th front axle as possible, and the drive motor close to the rear axle. The secondar

actuator (where used), receiver, receiver battery and drive motor battery have then to be accommodated in the remaining space available. Almost inevitably this results in the receiver being close to both the actuator motor and the drive motor, so particular attention will have to be given to suppression (see Chapter 6). Sliding metal-to-metal movements may also be located close to the receiver, in which case these may need bonding or insulating (see Chapter 11).

Less conventional systems

An alternative method of model vehicle control is to provide individual drive to two of the wheels by separate electric motors. A single-channel pulse proportional system can then be used to vary the supply to the individual motors through variations in signal/mark/space ratio. Thus with a 50:50 mark/space ratio both motors receive an equal supply, and hence run at the same speed, so the model drives straight. Variations in mark/space ratio then 'favour' one motor or the other as regards supply (because one motor will have more 'on' time than the other), thus providing steering through the different speeds of the driving wheels. Since the mark/space ratio is infinitely variable, steering is truly proportional.

Such a system can be applied directly for steering a tracked vehicle. For proper steering control of a wheeled vehicle it is necessary that the powered wheels pivot as well as 'power steer', which adds considerably to the mechanical complexity. The main alternatives which have been tried – and found to work – are:

(i) mounting each drive wheel so that the motor pivots with it

(ii) taking the drive from each motor via a flexible shaft to its respective (pivoted) driven wheel

(iii) pivoted wheel with fixed motor position, with drive through gearing capable of accommodating the pivoting motion.

CHAPTER NINE

SINGLE-CHANNEL PROPORTIONAL

Simple single-channel operation work with an 'on-off' signal from th transmitter, where 'signal on' is used to move an actuator to a contro position and hold it in that position (S/N type actuator); or given in the for of a 'quick-blip' to trigger the movement of a secondary actuator from or position to the next. Control positions are thus either 'on' or 'off' – e. in the case of a rudder movement 'full rudder' or 'no rudder' (neutra Intermediate *response* on the part of a model to this type of bang-ban control, as it is called, can only be obtained by 'timing' the duration of th 'on' signals and the spacing between them.

This principle can be carried further by 'timing' the transmitter signa electronically, so that it is *continually* sent out in a series of *pulses* of 'signa on-signal off – etc.' At the same time provision is made to vary the timing the pulses by movement of a control lever, producing what is known as *pulse proportional signal*.

There is no need to bother about the electronics involved. Pulse (propo tional) transmitters replace the normal keying button with a stick contro movement of which automatically varies the pulse proportional signa transmitted continuously as soon as the transmitter is switched on. Th principle of operation is worth studying, however, for it is really qui simple.

A pulsed signal is a repetition of on-off signals. An 'on' signal is known a *mark,* and an 'off' signal as *space*. Equal durations for 'on' and 'off' woul thus give equal marks and spaces, or a 50:50 *mark/space ratio* – Fig. 9.1.

For technical reasons the duration or length of a mark *plus* a space always the same. Thus if the duration of the *mark* signal is increased, that o

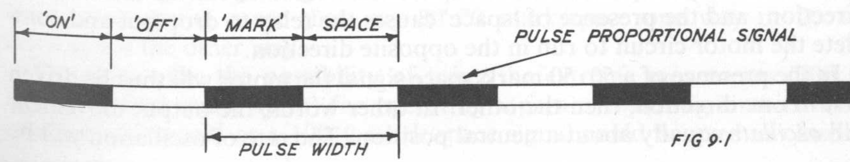


FIG 9.1

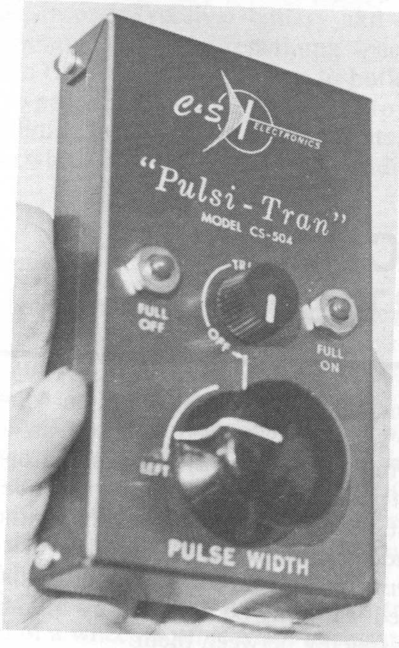


Plate 38 'Galloping Ghost' or pulse-proportional requires the use of a special transmitter, or pulser, to combine with a standard transmitter. Note this unit also provides separate pushbutton controls for full movement to one extreme or the other

the space is correspondingly reduced, and vice versa. Possible variation is from 'all mark' or 100:0 mark/space ratio; to 'all space' or 0:100 mark/space ratio – Fig. 9.2. Any intermediate value of mark/space ratio is obviously possible, the signal being infinitely variable between these two limits.

This is still a *single-channel* radio signal, but a *variable* one rather than a simple on-off signal. To utilise the variable nature of the signal, some method of *decoding* the signal must be applied at the receiver end. The simplest method is to use a special type of actuator to decode the signal, so that the system can then be worked with an ordinary single-channel receiver.

In practice the most suitable type of actuator is an electric motor driving an output movement through suitable reduction gearing – i.e. a special form of motorised actuator. This is connected to a relay receiver and a centre-tapped battery, as shown in Fig. 9.3, so that the presence of 'mark' signal causes the relay to pull in and complete the motor circuit to drive in one direction; and the presence of 'space' causes the relay to drop out and complete the motor circuit to run in the opposite direction.

In the presence of a 50:50 mark/space signal the motor will thus be driven first in one direction, then the other. In other words, the output movement will *oscillate* equally about a neutral position. The rate of oscillation will be

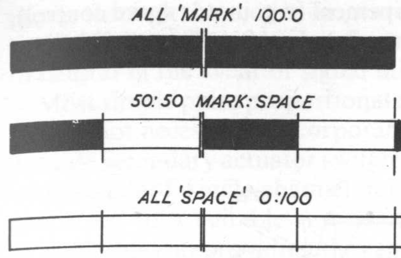


FIG. 9.2

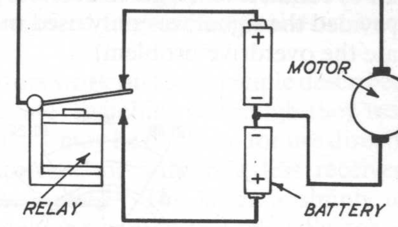


FIG. 9.3

the same as the *pulsing rate* of the mark/space signal – i.e. if each complet mark plus space signal occupies one tenth of a second, the pulsing rate wil be 10 pulses per second, and the motor will oscillate at this same rate. If th output is linked to a rudder, the rudder movement will follow the sam oscillations, at the same rate. This 'waggling rudder' is an inevitable, an characteristic, feature of pulse proportional systems. Its effect will b discussed a little later.

First see what happens if the mark/space ratio is changed. Increasing th mark/space ratio will give the motor a longer time of driving in one directio than the other – say a longer period of right rudder than left rudder. This i basically the same result as the technique of operating rudder control wit ordinary single-channel operation – more time on right rudder than lef will produce a turn to the right. Another way of looking at it is to think i terms of 'bias'. More time driving to one side obviously biased the *effectiv* rudder movement in that direction.

Where this differs from simple single-channel working is that the bias i variable. Thus a 60:40 mark/space ratio would give a little bias to the right a 70:30 mark/space ratio more bias to the right, and so on up to 100:0 mar space ratio where the drive would be continuously to the right, with th movement arrested only by mechanical stops. Similarly, varying the mark space ratio from 50:50 to 40:60, 30:70, etc., would produce an increasin bias in the opposite direction (left rudder). The effective rudder bias, there fore, is *proportional* to the mark/space ratio of the signal, and fully variabl following variations in the mark/space ratio of the signal.

For practical applications a little 'tidying up' is necessary. A 100:0 o 0:100 mark/space ratio signal is an embarrassment, since it results in th motor driving continuously in one direction or the other, calling for mechani cal stops to limit the control movement, and a slipping clutch on the motor t avoid stalling it. The answer is to limit the amount of mark/space ratio use for normal signalling – e.g. extreme movement of the transmitter contro lever never giving more than say 80:20 mark/space one way or 20:8 mark/space the other way.

This does offer the possibility of using the extreme movements (100: or 0:100 mark/space ratio) for operating separate switching circuits. Fo example, all 'mark' or a 100:0 mark/space signal could be used to close a

pair of contacts to trigger a secondary escapement (e.g. motor speed control), provided the signal was only used momentarily – Fig. 9.4. This would eliminate the overdrive problem).

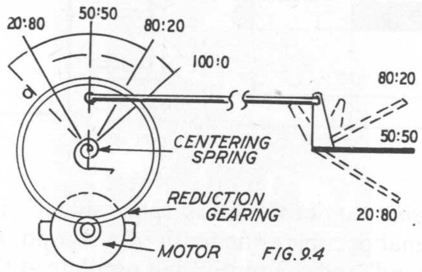


FIG. 9.4

The 'all space' or 0:100 mark/space signal could also be used to switch a third actuator, but could much better be used as a 'fail safe' device. Operation of the pulse proportional actuator depends on the *continual* presence of a signal. Should the radio link fail, this would give the equivalent condition of an 'all space' signal, causing the motor to drive continuously in one direction, only limited by any mechanical stops present. This would mean full rudder movement locking on.
If this position operates a switch to break the motor circuit, however, this will at least prevent the motor from being overheated and the battery flattened. But the control position cannot be returned to neutral by simple mechanical means, e.g. a self-centering spring, as this would not be able to rotate the

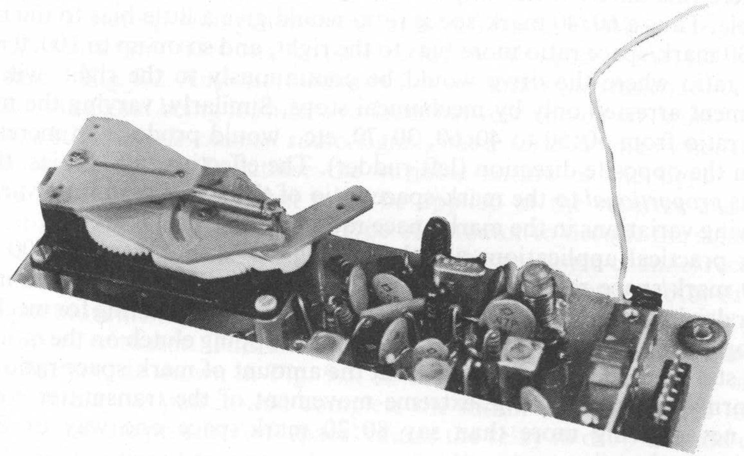


Plate 39 Pulse proportional needs a special actuator to 'decode' the variable signal in terms of suitable mechanical output. Here a Rand LR-3 actuator is shown mounted on a receiver panel together with additional electronic switching circuits

motor through the reduction gearing involved. A rather more sophisticated type of 'fail safe' switching is therefore required to give electrical drive back to neutral in the event of signal failure.

Most simple pulse proportional actuators work on the principle described but do not necessarily incorporate 'fail safe' switching (although they may provide secondary actuator switching). They may be designed for use directly with standard single-channel relay receivers, or with relayless receivers connected to a suitable *reverse polarity switcher*. The latter is simply an electronic circuit providing the same switching function as a relay. Switchers may also incorporate additional 'fail-safe' or pulse omission detector circuits.

The waggling rudder

On the mechanical side we have still to elaborate on the effect of a continually oscillating or 'waggling' rudder. At slow pulsing rates this will result in a weaving path followed by the model, with the turning effect biased in one direction or the other once the mark/space ratio is altered from 50:50 – Fig. 9.5. In the case of aircraft, at least, this weaving effect becomes less and less noticeable as the pulsing rate is increased, until at pulse rates of about 4–5 per second* the fact that the rudder is oscillating continuously (virtually vibrating, at this rate!) has virtually no effect at all. Thus pulse generators incorporated in the transmitter are usually designed to operate at rates of the order of 10–16 pulses per second, or slightly higher.

The only other requirement is then that the receiver relay be capable of following the signal pulse rate accurately. Thus a sluggish relay capable only of following a pulse rate of, say, 5 pulses per second would be quite unsuitable for use with a transmitter generating a signal pulse rate of 10–15 pulses per second. Most standard relays used in modern receivers are, however, capable of following pulse rates of this latter order, or even higher.

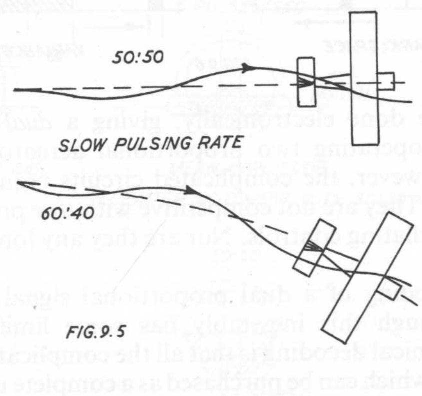


FIG. 9.5

* This depends on the design and 'sensitivity' of the model.

The same limitation does not apply with electronic switchers used in place of relays since these can follow much higher pulse rates, if necessary. There is a theoretical advantage in increasing the pulse rate for aircraft controls, but there are practical limitations. Thus when the pulse rate reaches about 25 pulses per second, the damping provided by the inertia of the mechanical linkage and the rudder itself, can prevent the system working. For similar reasons, lower pulse rates are usually best for model boat rudder control, where the damping forces on rudder movement are even higher. Another important point is to ensure that the transmitter pulse rate is matched to the design operating pulse rate of the actuator used. Pulse transmitters may be produced with a fixed pulse rate, or one which can be varied by simple adjustment.

Dual pulse proportional

With the pulse proportional system so far described, adjustment or selection of pulse *rate* has been described in terms of suiting the performance of the model – i.e. fast enough so that 'rudder waggle' effect is not apparent, but slow enough for inertia forces in the output movement to be negligible. There is, however, the possibility of adding a second method of proportional signalling superimposed on variable mark/space ratio by making the *rate of pulsing* also variable, provided this second variable signal can also be decoded – Fig. 9.6.

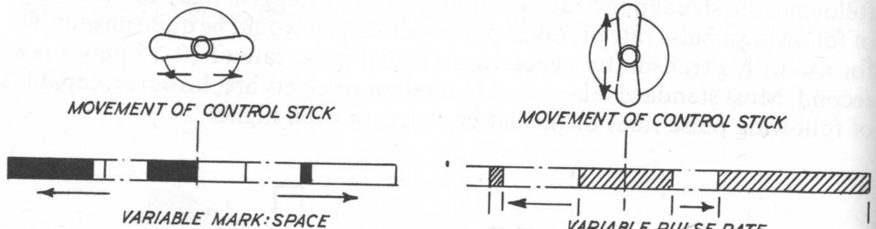


FIG. 9.6

Decoding can be done electronically, giving a *dual pulse proportional system* capable of operating two proportional actuators separately, and simultaneously. However, the complicated circuits required are not really justified in practice. They are not competitive with *true* proportional systems which eliminate oscillating controls. Nor are they any longer 'simple' single-channel systems.

Fortunately, decoding of a dual proportional signal can also be done mechanically, although this inevitably has some limitations. The great advantage of mechanical decoding is that all the complication is in the special design of actuator – which can be purchased as a complete unit. Thus standard receivers can be used. The transmitter design is little more complicated than that of a single pulse-proportional type, since pulse-rate variation can be

added by relatively simple circuitry. It is usual to combine the two contro on one 'universally mounted' stick – movement from side to side givin variations in mark/space ratio; and movement up and down giving variatio in pulsing rate.

Such dual systems, using special actuators, are known as 'Galloping Ghos or 'Simple-Simul' (simple simultaneous). The principle of operation depen on linking the mechanical output of the actuator to both rudder and elevato as shown in Fig. 9.7, and is thus essentially for aircraft control only. Bo rudder and elevator are driven with a continuous oscillatory motion.

As before, the amount of rudder bias depends on the mark/space rati of the signal. Elevator bias is provided by varying the pulse rate. This effe can be followed by a study of Fig. 9.8. To start with, suppose the 'rudde signal is a constant 50:50 mark/space ratio. The rudder will be oscillating a

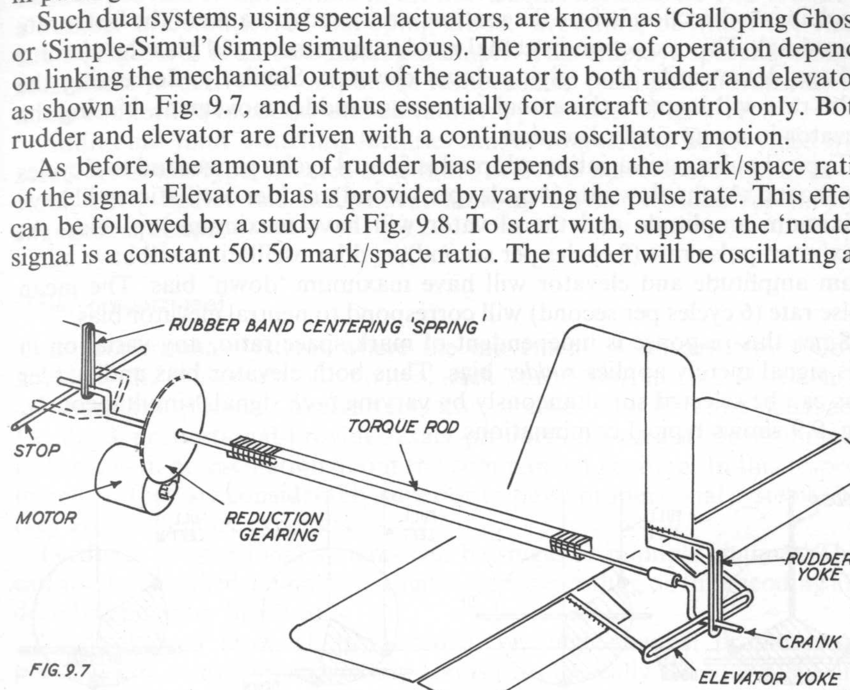


FIG. 9.7

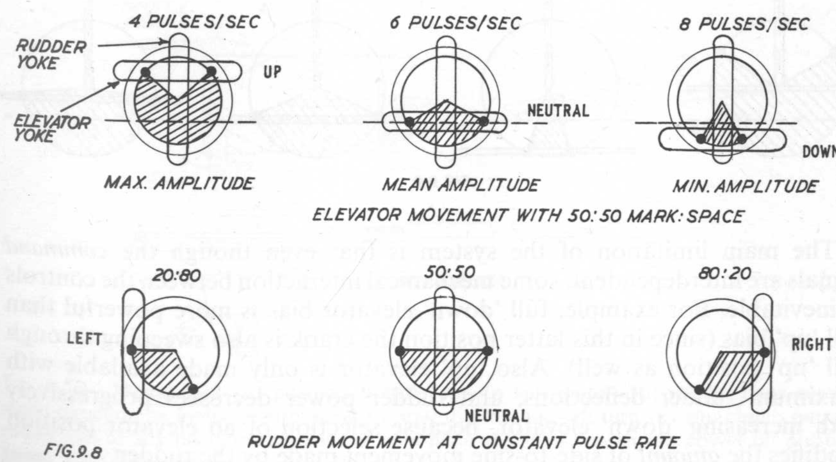


FIG. 9.8

equal amount in either direction about neutral, equivalent to neutral rudder position, this rate of oscillation being equal to the pulsing rate.

Now consider the effect of speeding up the pulse rate. The rudder will oscillate equally about its mean position, as before, but it will not drive so much in one direction before the motion is reversed (because of the faster rate of cycling). This reduction in actual rudder movement will bias the *elevator* linkage downwards, thus giving down elevator. Similarly, decreasing the pulse rate will increase the actual amount of rudder movement, biasing the elevator in an upwards direction.

Typical pulse rate variation adopted is from 4 cycles per second to 8 cycles per second. At the slow rate (4 cycles per second), rudder oscillation will have maximum amplitude and the elevator will have maximum 'up' bias. At maximum pulse rate (8 cycles per second), rudder oscillation will have minimum amplitude and elevator will have maximum 'down' bias. The mean pulse rate (6 cycles per second) will correspond to neutral elevator bias.

Since this response is independent of mark/space ratio, any variation in this signal merely applies *rudder* bias. Thus both elevator bias and rudder bias can be selected simultaneously by varying *both* signals simultaneously. Fig. 9.9 shows typical combinations.

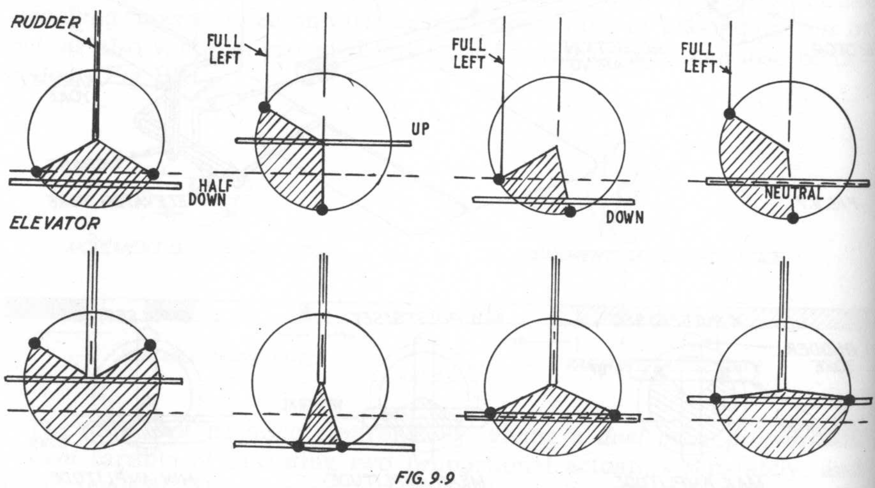


FIG. 9.9

The main limitation of the system is that even though the *command* signals are interdependent, some mechanical interaction between the controls is inevitable. For example, full 'down' elevator bias is more powerful than full 'up' bias (since in this latter position the crank is also sweeping through full 'up' position as well). Also 'up' elevator is only made available with maximum rudder deflections, and rudder power decreases progressively with increasing 'down' elevator, because selection of an elevator position modifies the *amount* of side-to-side movement made by the rudder.

These limitations can be partly overcome by further adjustment of th geometry. For example, to adjust the elevator power a differential movemen can be used – more 'up' than 'down'. A better system is to adjust the linkag form to provide compensation in the movements themselves. This is done i a number of commercial 'Galloping Ghost' actuators, of which the Ran LR-3 (Fig. 9.10) is an outstanding example. This employs specially shape cam plates to derive the outputs as compensated push-pull movements fo direct connection to rudder and elevator via pushrods – Fig. 9.11.

Additional 'limit' switching facilities can, of course, also be provided wit actuators of this type, selected by a 100:0 or 0:100 mark/space signal. In th Rand LR-3 again, one mechanical limit switch is provided for thrott changeover action.

'True' proportional

True proportional systems where the movement of an actuator follow faithfully the movement of a control stick at the transmitter end are base on more complicated receiver/actuator circuits incorporating feedbac Feedback proportional provides exact proportional control positioning c controls with no oscillation about the commanded position. In this respec therefore, they are considerably superior to pulse proportional systems; bu they are much more expensive.

Feedback proportional systems can be single or multiple channel. The can also be classified as analog or digital type, depending on the encoding an decoding circuitry involved.

Single-channel feedback proportional or single-channel proportiona provides one control function only and is thus basically the equivalent of simple single-channel system, except that actuator provides infinitely variab

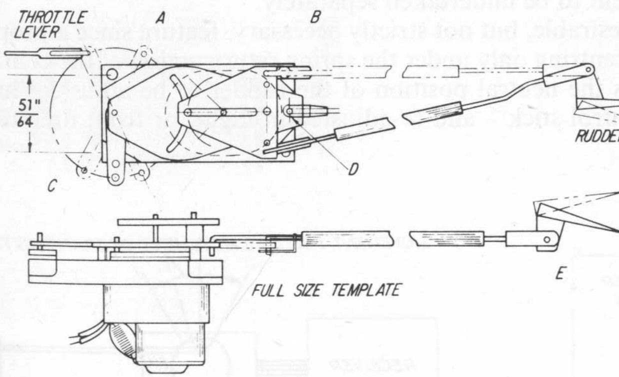


Fig. 9.10 Model LR3 (a) position throttle arm to suit motor, (b) rudder plate rotat same direction as motor control lever for low throttle and left turn (c) slip clutch perm movement to any position (d) elevator cam plate (e) solid line shows power off positi (note: horn below hinge)

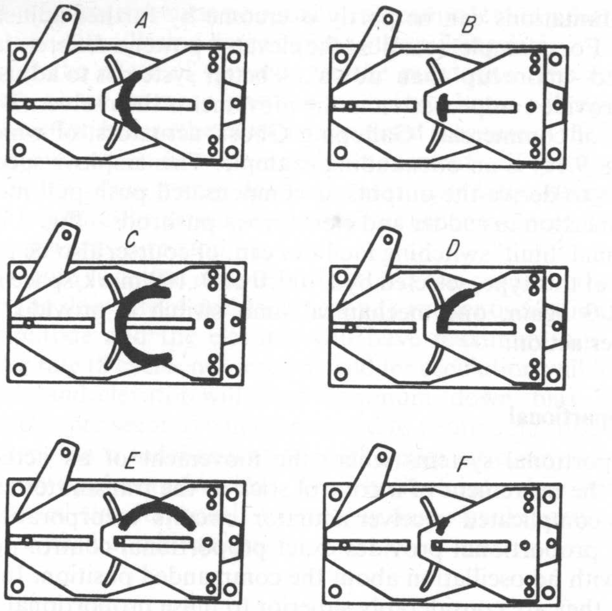


Fig. 9.11 'Galloping Ghost' actuator. A The arc is at neutral pulse width and rate for straight flight. B This arc trace is at full down. No turn is had in this trace. C The view of the arc giving you full up, again there is no side motion. D A full turn arc. For opposite turn the arc is on the opposite side. E The arc shows full up and full turn. Opposite turn on opposite side. F The view of the arc shows a full down and full turn

fully proportional movement to operate one control service, which in practice would be rudder – Fig. 9.12. A separate *trim* control is also available, enabling fine adjustment to be undertaken separately.

This is a desirable, but not strictly necessary, feature since a proportional servo is self-centring only under the spring return action of the control stick. Trim enables the neutral position of the rudder to be adjusted 'hands off' the main control stick – and re-adjusted in flight, or from time to time, if necessary.

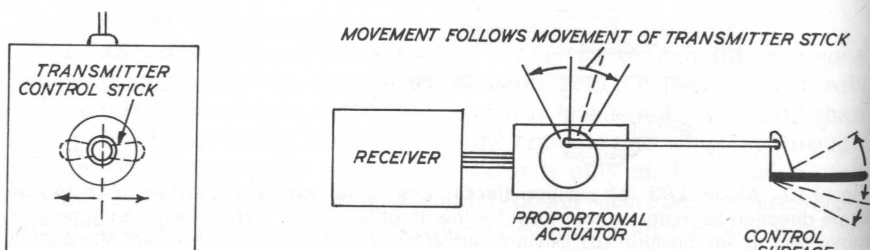


FIG. 9.12

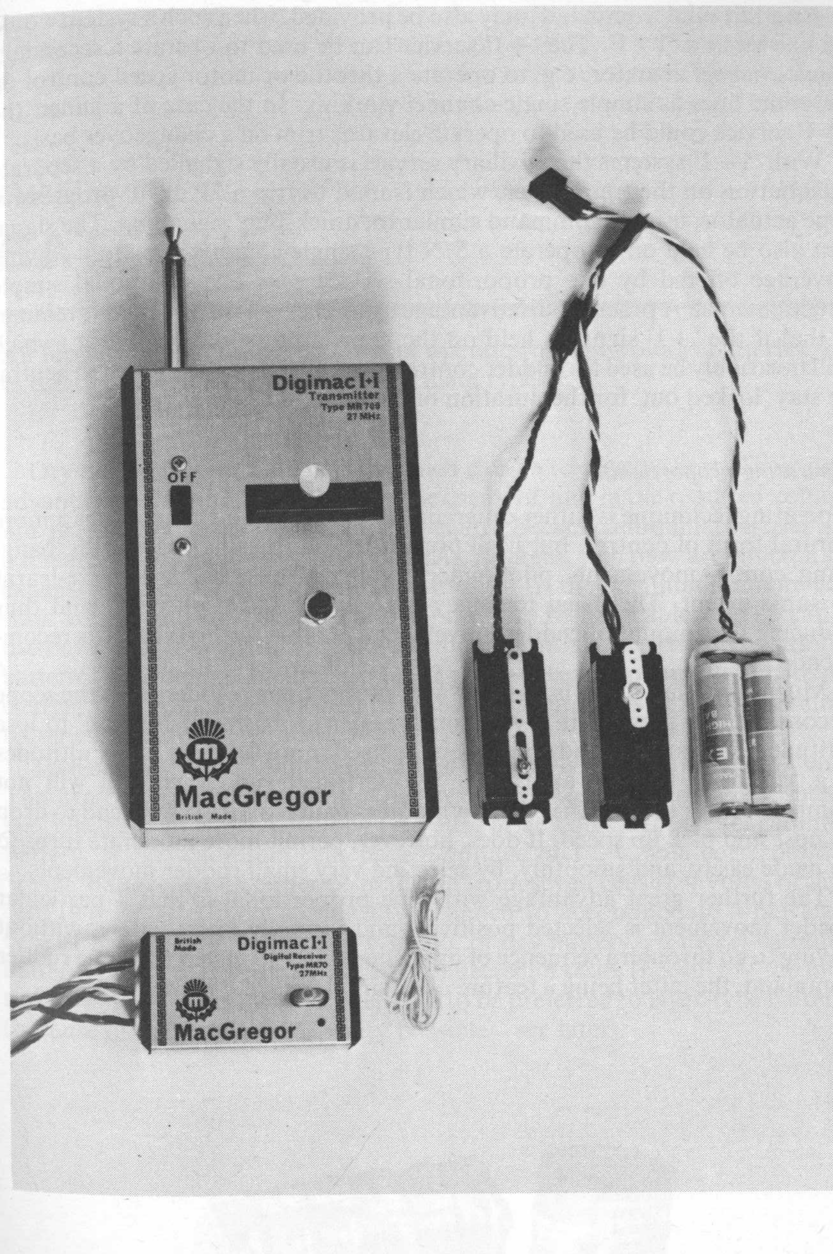


Plate 40 The ultimate as far as variable control is concerned is true proportional, where the control movement faithfully follows movement of the transmitter control stick. This modern '1 + 1' equipment has one fully proportional service and one non-proportional service – hence two actuators

An additional 'command' may also be provided, when such a system would be known as a '1 + 1'. The '+ 1' service can be used to operate a secondary *single-channel* actuator, e.g. to operate a throttle or motor speed control on the same lines as simple single-channel working. In the case of a glider, the '+ 1' service could be used to operate elevator trim on a changeover basis.

With '1 + 1' systems the auxiliary service is usually signalled by a separate pushbutton on the transmitter, which is used to trip a 2P or 3P progressive type actuator, using a command similar to 'quick-blip' signalling. The signal can also be held on to operate a S/N type single-channel actuator – giving coverage offered by one proportional service plus one additional simple single channel. A practical disadvantage using the '+ 1' facility in this manner is that if the '+ 1' signal is held on the main proportional actuator (which will invariably be used for rudder control), will usually either return to neutral or stay 'locked out' for the duration of the held '+ 1' signal.

Operating proportional

Operating technique is rather different to normal single-channel. It is a more natural form of control, but if all previous experience has been with 'bang-bang' control movements, piloting technique with aircraft has to be re-learnt to some extent. The usual tendency is to over-control at first – and thus reducing the amount of rudder movement available for first flights is recommended.

Much smoother flying is possible with proportional rudder; also the scope is considerably greater. It is very much easier to master 'fishtailing' to lose altitude, for example; and rudder can be used more safely at lower altitudes (e.g. during a landing approach). Proportional rudder control will not compensate for the fact that when a model is made to turn it will tend to drop its nose and pick up speed. It does, however, permit more moderate turns to be made easily, and smoothly, by selecting very small rudder movements.

The further great advantage with true proportional is that a particular rudder movement is selected positively and virtually immediately, without having to go through a sequence of opposite rudder to repeat the same rudder command, the latter being a feature of all simple single-channel systems.

CHAPTER TEN

BATTERIES

All modern radio control equipment operates on low voltage batteries, an selection is normally made from two main types:

(i) dry batteries.
(ii) nickel cadmium accumulators.

Dry batteries have a single life, which can be relatively short. Their mai advantage is that they are relatively inexpensive, and in the required voltag are reasonably small and light in weight. Nickel-cadmium batteries ca compare in bulk and weight for similar voltages, but they are much mor expensive. They have two main advantages – (i) they maintain a more co stant voltage during discharge and (ii) they are rechargeable, and so can b used over and over again almost indefinitely. Initial cost of nickel-cadmiu batteries is, of course, further increased by the necessity of buying a matchi charger, but this can be selected to match all future sizes of nickel-cadmiu batteries you are likely to use.

Transmitter battery voltage required is usually of the order of 9 volt This can be provided by a *layer type* dry battery; a series of dry cells, such pencells, each of which develops 1·5 volts; or an equivalent nickel-cadmiu battery. Nickel-cadmium cells have a voltage of 1·2 v, so a correspondi '9 volt' battery would either be made up from seven cells (8·4 volts) or eig cells (9·6 volts). Unless specifically designed to accommodate a particula type of battery (e.g. a specified type no. of dry battery); a nickel-cadmiu battery is to be preferred to dry cells connected in series (because of the mo stable characteristics); and dry cells are to be preferred to layer-type batteri (because of the increased capacity possible – see later).

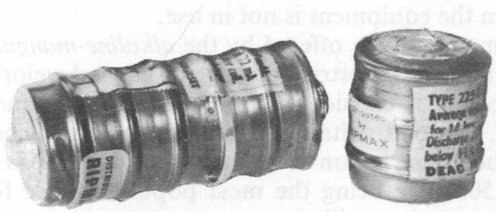


Plate 41 Nickel-cadmium batteries are better than dry batteries for RC work

Receiver battery voltage required may range from 3 volts to 4·5 volts, or even 6 volts, depending on the receiver design. Alternative battery types are dry batteries (1·5 volts per cell), and nickel-cadmium accumulators (1·2 volts per cell). Again the latter type are to be preferred because of their better load-voltage characteristics, especially for relayless receivers.

Actuator battery requirements may range from 1·5 volts (e.g. for secondary actuators) to 3 or 3·5 volts; or in some cases 4·5 volts. Again the choice is between dry cells (usually pencells) and nickel-cadmium accumulators, with the same comment as above. If the voltage cannot be 'matched' – e.g. a single nickel-cadmium cell would only give 1·2 volts against the nominal 1·5 volts requirement, say – then it is generally acceptable to adopt the next size up ($2 \times 1{\cdot}2 = 2{\cdot}4$ volts for the example quoted), unlike receiver battery voltages which should match the specification as closely as possible. Many receivers, however, will be specified as having a tolerance on voltage – e.g. 3 to 4·5 volts. In this case it would be advisable to work to the 'maximum' value in the case of dry batteries, whilst any intermediate value would be suitable with nickel-cadmium accumulators. Thus for the tolerance quoted above, choice would be (i) three dry cells = 4·5 volts or (ii) three nickel-cadmium cells = 3·6 volts.

Dry cell types

Dry cells are available in a number of different standard sizes, specified by type code, both as single sizes and series-connected batteries – see Table VIII. Table IX gives equivalents in various proprietary makes.

In addition, certain sizes are available with different *types* of construction. The standard or ordinary type, which is the cheapest, is the least suitable for radio control work, especially where high current drains are involved (e.g. for actuator batteries, or relayless receiver batteries). The *high power* (HP) cell is a much better proposition, having about twice the life of a standard dry cell of the same size under conditions of higher current drain. Under low or moderate current drain the difference in performance of the two types is less noticeable.

A further advantage offered by the HP type of dry cell is that the construction is leakproof. This means that batteries left in situ and allowed to go flat will not corrode through and leak. Normally this should not be a significant factor for dry batteries should *never* be left in a transmitter or radio control installation when the equipment is not in use.

Better performance still is offered by the *alkaline-manganese* dry battery. This is only available in a restricted range of sizes, developing 1·5 volts per cell, but the capacity is considerably greater, for the same size, compared with an HP cell, the load/voltage curve is much flatter, and the shelf life is better. Again the construction is leakproof. Standard sizes are shown in Table X, the '1500' size being the most popular choice for radio control work as equivalent to 'pencell' size.

Nickel-cadmium batteries

Nickel-cadmium batteries are popularly known as 'DEAC's' after the name (initials) of the original manufacturer. A number of other companies now produce nickel-cadmium batteries essentially similar in appearance and performance. The two most popular sizes are the '225' (or equivalent) and the '500' (or equivalent) – see Table XI. The numbers refer to the capacity of the cells discharging at the 10 hour rate, e.g. a 225 cell will discharge at 22·5 milliamps for 10 hours, and substantially pro rata for other discharge rates.

Nickel-cadmium batteries comprise a number of cells connected togethe by welding, enclosed within a plastic outer covering and with suitable enc terminals fitted. Standard battery sizes (in both 250 and 500 sizes) are shown in Table XII.

Nickel-cadmium batteries are virtually indestructible, provided they are not excessively overcharged. This can cause them to overheat (causing interna damage) and swell. Matching chargers are normally designed to re-charg nickel-cadmium batteries at the 10 hour rate, i.e. charging current in milli amps equals capacity number divided by 10. Time to complete a full charg is then 14 hours. However, in normal use nickel-cadmium batteries are neve fully discharged – and it is difficult to estimate just how much charge has beer used up.

This is no problem. Charging at the proper (10 hour) rate, the charging time can be doubled without harming the cells in any way. Thus normally a safe discharge time would be 10 hours for the battery in any condition, unles it is known that the battery is virtually completely discharged, when the full 14 hour charge time can be given.

The only thing that really needs watching with a nickel-cadmium batter charger is to see that the battery being charged is connected to the righ charger output (or the charger switch put to the right position). Differen *size* batteries need different charging rates, and different battery *voltage* need different charging voltages. This is usually provided for in the desig of the charger. Wrong connections (or wrong switching of the charger will thus overcharge or undercharge the size and voltage of battery connecte to it.

Table VIII Standard sizes or dry batteries

*Type**	*Nominal voltage*	*Weight (gr)*	*Size (millimetres) Length or diameter*	*Width*	*Height*	*Recommended current range (mA)*	*Contacts diagram*
U12 (Pencell)		25	14·3	—	50	20–30	E base
U11		45				20–60	,,
SP11		45	26	—	50	20–60	,,
HP11		45				0–1000	,,
U2	1·5	90			9	10–50	,,
SP2		90	34	—	60	10–50	,,
HP2		90				0–2000	,,
AD4		600	67	67	102	100–250	2-pin socket
FLAG		880	67	—	166	100–250	2 screws
1839	3		26		100	20–60	2-pin socket
PP11		450	65	52·5	91	10–100	4-pin socket
126	4·5	370	103	35	91	0–250	2 screws
AD28		450	100	35	106	30–300	2-pin socket
481		1130	113	66	165	100–250	2 screws
PP1		283	65	56	56	5–50	snap fasteners
PP8	6	1100	65	52	200	20–150	snap fasteners
996		580	67	67	102	30–300	2 screws
991		1500	136	72	125	30–500	2 screws
PP3		38	26·8	17·5	48	0–10	snap fasteners
PP4		51	25·4	—	50	0–10	snap end fasteners
PP6		142	36	35	70	2·6–15	snap fasteners
PP7	9	200	46	46	62	5–20	snap fasteners
PP9		425	66	52	81	5–50	snap fasteners
PP10		1250	65	52	225	15–150	2-pin socket
PP11		459	65	52	91	5–50	snap end fasteners

* Ever Ready type number (equivalents are to be found in other makes – see Table IX). Type numbers in **bold** are world standards.

Table IX Carbon-Zinc battery equivalents

UNITED KINGDOM					
Ever Ready	U2 HP2 SP2	U11 HP11 SP11 C11	HP7 D14	U16 HP16	D23
Exide (Drydex)	T2 SP2 HP2	T15 SP11 HP11	HP7 T5	U16 HP16	DL33
Ray-O-Vac	D2 RR13 2LP HC2	RR14 1LP C1 HC1	7R RR15	—	—
Vidor	HP2 V2 LPV2 VT12	HP11 V11 LPV11 VT13	V12 HP14 VT14	HP16 V16	—
CONTINENTAL					
Berec	U2 LPU2 SP2 PP12	U11 SP11 PP13	U7 U12 PP14 PP15	U16	D23
Cipel (Mazda)	GT1 F20 P20 LF20	MT1 RFM LF14	AC1 LF6	RFB	PA1 PC1
Daimon	253 289 250 251	258 259 287	298 296	291 294	292 295
Hellesens	VII-33 VII-34 VII-36 VII-37	VII-24 VII-25 VII-26 VII-27	VII-28 VII-38 VII-75 18	17	14
Leclanché (France)	T1 R20 R20S	R14 R14S	R6 R6S HA6	RO3	R1
Leclanché (Suisse)	208	207 604	201 202 601 602	—	—
P.L.B.	E2 E4 E7	E5	E15 E18	—	—
Pile Wonder	EXPOR MARIN AMIRO	BABIX JUNON ESCAL	SONAT VEBER NAVAL	EXTAZ	SAFIR
Superpila	60	61	63 433 AC7	68	67
Varta (Pertrix)	211 212 222 232	214 235 236 213 233	244 251 284 280	239	245 249
Witte Kat	667	668	666	—	665
JAPAN	UM1	UM2	UM3	UM4	UM5

Table Xa Standard alkaline-manganese cells

Mallory Type No.	*Diameter in.*	*mm*	*Height in.*	*mm*	*Weight oz.*	*gr.*
Mn-625G	0·610	15·5	0·238	6·1	0·106	3
Mn-825	0·905	23	0·228	5·8	0·245	7
Mn-1	0·625	15·9	0·645	16·4	0·336	9·5
Mn-9100*	0·455	11·6	1·130	28·7	0·340	9·6
Mn-2400	0·405	10·3	1·745	44·3	0·400	11·3
Mn-1500	0·555	14·1	1·960	50	0·820	23·2
Mn-1400	1·020	25·9	1·940	49·3	2·340	66·5
Mn-1300	1·315	33·4	2·377	60·4	5·030	142

Table Xb Equivalent sizes of 1·5 volt cells

Alkaline–Manganese (Mallory)	*Carbon–Zinc (Ever Ready)*	*International*
Mn-9100	D23	N
Mn-2400	U16/HP16	AAA
Mn-1500	U12 (pencell)	AA
Mn-1400	U11/SP11/HP11	C
Mn-1300	U2/SP2/HP2	D

Table XI Standard sizes of nickel-cadmium cells

Type	*Capacity*	*Diameter*		*Thickness*		*Weight*	
	Ah	*in.*	*mm*	*in.*	*mm*	*oz.*	*g*
DEAC 225	0·225	1	25	0·36	9·0	0·5	14·25
500	0·50	1·35	34·4	0·39	9·7	1·0	28·5
Ever Ready							
NCB 9	0·09	0·9	22·7	0·21	5·2	0·23	6·5
NCB 20	0·20	1·0	24·8	0·29	7·4	0·39	11·0
NCB 28	0·28	1·35	34·4	0·21	5·3	0·58	16·5
NCB 55	0·55	1·35	34·4	0·37	9·45	1·00	28·5
NCB 90	0·90	2·0	50·5	0·33	8·3	2·26	64
NCB 175	1·75	2·0	50·7	0·59	14·9	3·53	100

Table XII Made up nickel-cadmium batteries

No. of cells	2	3	4	5	6	7	8	9	10
Voltage	2·4	3·6	4·8	6·0	7·2	8·4	9·6	10·8	12·0
Weight (oz)									
225 DEAC	1	1½	2	2½	3	3½	4	4½	5
500 DEAC	2	3	4	5	6	7	8	9	10

CHAPTER ELEVEN

RADIO CONTROL OPERATION

Virtually all modern single-channel transmitters are crystal controlled an are correctly adjusted at the factory to give maximum radiated output at specific frequency, this frequency being controlled by the 'spot' frequenc of the crystal employed. They should not require readjustment during norma usage, unless subject to accidental damage. In that case they are best returne to the manufacturers, or a reputable service agent, for attention.

Some single-channel transmitters may be fitted with an output mete Whilst this is usually coupled into the circuit to indicate the strength of th current in the output circuit, its main function from the user's point of vie is to indicate the state of the transmitter battery. A low meter reading is warning that the battery is running down and should be replaced. Such meter may also be used to 'peak' transmitter tuning, where tuning adjustme is provided in the design. If this is applicable, then the instructions supplie with the transmitter will explain exactly how tuning adjustments should b made.

Transmitter-receiver combinations are normally factory pre-tuned. Tha is, the receiver is already tuned to the transmitter frequency. In the case of superhet receiver, no attempt to adjust the tuning *of either the transmitter o receiver should be attempted* by the average user.

With a *superregen* receiver the position is a little different. The receive may be factory-tuned to the transmitter, but not necessary with optimu tuning. This is partly because factory tuning is done under 'close rang conditions, coupled with the fact that the tuning of a superregen receiver quite broad in any case. Other things can also alter receiver tuning in a installation, such as the length of receiver aerial wire actually used. The bas rule here is to use the aerial length supplied fitted to the receiver, stretche out in a straight length as far as possible.

Superregen receivers are normally provided with a single tuning contr which can be adjusted by the user for optimum tuning. This takes the for of a metallic 'slug' fitted inside the tuning coil, with a slotted end accessib through a hole in the receiver case. The slotted end fits a 'screwdriver' blad (or in some cases a hexagonal key). *Only a non-metallic screwdriver* (or ke must be used when making adjustments. The proximity of a metal tool wi

interfere with the circuit and give false adjustments. A suitable tuning tool can be made by filing down the end of a plastic knitting needle to fit the slug slot; or a special 'tuning wand' can be purchased (or may be supplied with the receiver).

Receiver tuning

No meter or other instrument is needed for making tuning adjustments. All that is necessary is to connect together the complete receiver installation (receiver, batteries and actuator(s)), switch on this circuit and find the response to the transmitter signal keyed on and off. With plug-together units, this is easy to do as an initial bench test. Where the complete installation has to be wired up, again this can be done as a bench test by using plug-and-socket connections. If not, it can be left until the various units and wiring have been installed in the model.

Use fresh batteries for both the transmitter and receiver circuits; and in the case of dry cells which fit into battery boxes, *be particularly careful to insert all batteries the right way round.* Reversal of battery polarity could damage transistors in the circuit concerned – or at least ensure that the circuit will not work.

Position the transmitter, with aerial fully extended, a few feet away from the receiver hook-up (or installation). Key the transmitter 'on', which should cause the actuator to operate. In the case of an escapement this will be observed as a 'click' as the escapement armature pulls in; a motorised actuator will 'drive' to its signalled position and stop.

Check the transmitter instructions to see if the transmitter can be operated with the aerial retracted. In the absence of any specific instruction to the contrary, it can be assumed that it can. (Some circuit designs can be overloaded by operating the signal key with the aerial retracted, with possible damage to transistors).

With the aerial retracted, check that the receiver circuit still responds to a keyed on signal. Repeat with the transmitter carried farther away until the receiver response is becoming marginal – i.e. it does not respond at all with a further increase in distance between transmitter and receiver. This is a set-up which can be used for *optimum receiver tuning* (see later).

The alternative is to check with the receiver aerial fully extended and carry the receiver away from it to a similar point where the response is 'marginal', representing extreme range. This is best carried out once installation is complete for the separating distance required to produce 'marginal' operation may be as much as half a mile, and is thus essentially a two-man job – one to work the transmitter and the other to carry and hold the receiver installation. Optimum receiver tuning is then carried out at this nominal maximum range.

Ideally, close range tuning should be carried out for initial adjustment, and then final receiver tuning at nominal maximum range. Of the two, tuning *at nominal maximum range* is the more important, but the more difficult to carry out. The reasons why both are described are:

(i) Close range testing establishes that the radio link is working anyway – or if it is not working, enables tuning adjustment to be undertaken to get it working (provided the fault does not lie elsewhere). It is always comforting to be able to check that the transmitter receiver link *is* working before completing an installation. Close-range testing also enables a single person to check and adjust receiver tuning, if necessary.

(ii) A long range check is the only sure way of confirming that the transmitter-receiver link is operating over a suitable distance. It also provides the most critical conditions for obtaining results, which makes it easier to 'peak' the tuning of the receiver.

(iii) On the other hand, if a range check shows the transmitter-receiver link working over a suitable range, *there is really no need to adjust the tuning of the receiver at all.* It is obviously working with a suitable range; and in the case of aircraft the actual ground-to-air range achieved will usually be two or three times greater than the maximum ground-to-ground range found by test. Thus a ground-to-ground range of half a mile would be quite adequate for normal aircraft operation. In the case of boats, a ground-to-ground range of twice that normally required would also be adequate. A proven test range of 200 yards would be suitable for most boat systems.

Operators may still want to check tuning adjustment, however, for that extra margin of safety. Tuning adjustment is quite simple, as described below.

Tuning adjustment

The same technique is applicable to both 'short range' and 'long' range checking. In the latter case it is necessary to pre-arrange hand signals between the person holding the transmitter and the other person at a distance with the receiver installation, so that –

(a) The transmitter operator can indicate to the receiver operator when he is holding a signal 'on' – e.g. free hand held up – or the transmitter signal is 'off' – e.g. free hand down by the side.

(b) The receiver operator can call for a transmitter signal 'on' and indicate whether he wants it held on or not. He will need it to be held on to adjust the receiver tuning. Suitable signals could be:

free arm held up calling for transmitter signal on.

free arm down release transmitter signal.

free arm held horizontally, then withdrawn hold on transmitter signal (giving time for adjustment). This will also leave both hands free for holding the model and making tuning adjustments. This signal can be cancelled by holding the arm horizontally, then sweeping down.

free arm moved up and down key signals on and off at regular intervals. This will check the working after adjustment. Cancelled by moving the arm down again.

Obviously there are other methods of signalling. The above is merely a suggested system. It has been described in some length, however, because for successful range tuning *it is imperative* for one operator to know what the other is doing, and for the receiver operator, who is adjusting the tuning, to be able to call for the signals he needs.

For tuning, *signal held on* is required. This causes the actuator to operate. The receiver tuning slug is then turned one way until the actuator drop out – i.e. the signal link has been lost – Fig. 11.1. The exact extent of this movement should be noted – e.g. it may be as much as a full turn or even more at close range, or less than a quarter of a turn at long range.

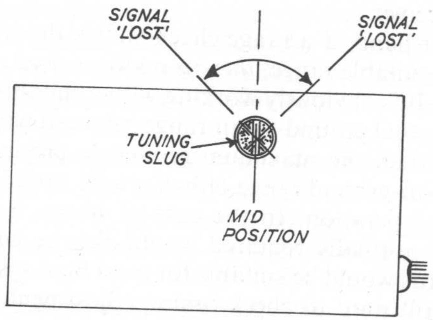


FIG.11.1

Call for *signal off*. Return the tuning slug to its original position and call for *signal held on*. Turn the tuning slug in the opposite direction until the signal is lost again, noting the exact movement.

The *optimum tuning position* is then set up by adjusting the slug to the middle position between these two extremes, which should be further checked as follows.

(i) With *signal off*, adjust slug to this 'middle position'.

(ii) With *signal held on*, check the amount of turn adjustment necessary on the tuning slug in one way for the signal to be lost. Then turn back again the other way picking up the signal and finally losing it again. Re-adjust the slug to the middle position between the two extremes. This should be the same as before, but it will not necessarily be so. If there is a considerable difference, increase the range to reduce the tuning 'swing' in both directions and re-adjust for the central position.

(iii) As a final check it is only necessary to see that the system responds exactly to repeated 'on-off' signals.

Two other points which are important in long range tuning are:

(i) In the case of aircraft, the model (or installation) should be clear of the ground, particularly damp ground, with the aerial stretched out freely and not touching the ground.

(ii) In the case of boats, the final tuning of the receiver should be made with the boat in water – not held in the hands or resting on the ground.

Modern transistor receiver circuits are usually quite stable and so once set up for optimum tuning they should stay on tune indefinitely. Thus it is unnecessary to repeat long range checks at regular intervals. A simple close range check is all that is necessary.

Trouble-shooting

Tuning is, of course, only one necessary feature for the proper working of a radio control link. Various other faults may be present, or can occur. For convenience of reference these possible causes and remedial actions required are best described in the form of a 'trouble shooting' table (see Table XIV).

Tuning indicators

A simple method of providing indication of tuning with a relay receiver is to insert a 0–10 milliammeter in one of the battery leads. This meter will then indicate the current flowing through the receiver circuit, which will be a low value (almost zero) when the receiver is switched on, rising to a steady higher value when responding to a transmitter signal – Fig. 11.2. Tuning can be adjusted with reference to the meter reading, turning the tuning slug one way or the other to find a position giving the maximum meter reading with the receiver responding to a transmitter signal.

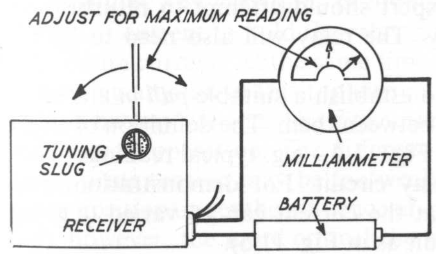


FIG.11.2

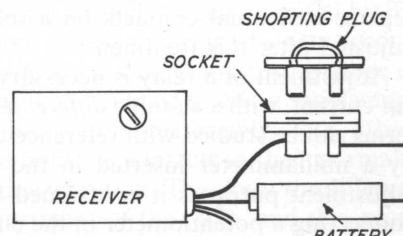


FIG.11.3

This method of meter-tuning can be incorporated as a permanent featur in an installation. One battery lead is broken by a socket, into which a milli ammeter can be plugged for tuning. After tuning, the meter is removed and shorting plug fitted to the socket to complete the receiver circuit – Fig. 11.3

Some receiver circuits incorporate a built-in tuning indicator in the form of a tiny bulb included in the circuit. This works in the same way as a meter the brightness of the bulb indicating the strength of the current flowin through the receiver circuit. Thus the bulb will glow when the receiver i responding to a transmitter signal and tuning is adjusted to give the brightes glow from the bulb.

Provision may also be made in some receivers to plug a deaf-aid earpiece int an appropriate point in the circuit, so that it is possible to hear the tone signa being received. Tuning in this case is adjusted to give maximum tone volume

Relay care and adjustment

Thanks to the fact that modern tone receivers operate with large current changes, relay adjustment is not usually critical. Relays are, in any case, normally pre-adjusted when supplied (either fitted to a relay receiver, or as separate slave relays to couple to a relayless receiver. Some relays are also 'sealed', meaning that they are enclosed in a separate casing. This is desirable to minimise the chances of dirt, etc., collecting on the relay contacts. This sealing enclosure may or may not be readily removable.

All relay contacts are, however, subject to 'wear' caused by electrical arcing. This can be reduced to a minimum by suppressing the contacts (see Chapter 6). The higher the current carried by the relay contacts, however, the more they will be subject to gradual deterioration through pitting and burning.

Contacts which are merely dirty can readily be cleaned by inserting a strip of stiff, clean paper between two contacts which are naturally closed and then pulling the paper clear. This should be repeated several times. Abrasive paper, or a flat file, should not be used for cleaning as damage to the contact surface could result. Abrading a contact surface may remove the metal contact material coating and also produce a roughened surface which can both increase contact resistance and make the armature movement stick.

Contacts badly damaged by burning or pitting, caused by carrying heavy currents, or lack of suppression, are best replaced. This usually means replacing the whole relay. Only an expert should attempt to refurbish or replace individual contacts on a relay. The relay will also need to be re-adjusted after this treatment.

Adjustment of a relay is necessary to establish a suitable *pull in* and *drop out* current, with a suitable *differential* between them. The definition of these terms can be studied with reference to Fig. 11.4 – e.g. typical readings given by a milliammeter inserted in the relay circuit. For demonstration, and adjustment purposes it is assumed that the current can be varied (e.g. by connecting a potentiometer in the circuit as in Fig. 11.5).

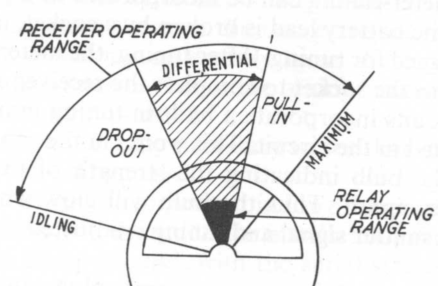


FIG. 11.4

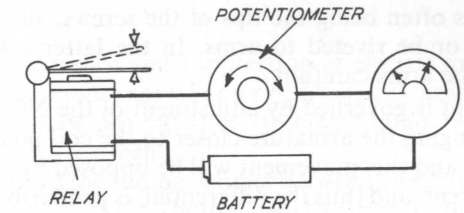


FIG. 11.5

Zero or near-zero current represents the idling condition of the receiver. If the current is gradually increased there will come a point where the relay armature is pulled in, moving from the NC (normally closed) to the NO (normally open) contact. This is the *pull-in* point. The relay will remain pulled in as the current is further increased, the maximum current representing the receiver current flow when responding to a transmitter signal.

If the current is back off from this maximum, a point will be reached where the relay armature drops out again, moving back to the NC contact. This is the *drop out* point, and the current will be a lower value than that for *pull-in*. The difference between the pull in and drop out currents is known as the *differential*.

Basically the *pull in* current wants to be about one mid way in the current range. This will eliminate any possibility of the relay being pulled in unwantedly by any variations in idling current, and at the same time give an excess of current to hold the relay pulled in strongly, when operated by the maximum current. At the same time there will be a margin of safety accommodating any fall in this top current to fall, e.g. due to increasing range or falling battery voltage. The *differential* is then adjusted to give a satisfactory mechanical operation. The differential needs to be reasonably close, otherwise spring tension may be too weak to hold the contacts in their normally open position under the influence of engine vibration. The closer the differential, however, the more critical the adjustment of the relay, and this again can make it susceptible to vibration. Thus with a current change available of 6–7 milliamps or more, as is common with modern tone receivers, a differential of 2 milliamps is usually quite acceptable.

Relays vary in design, but the basic layout of the majority of simple relays is as shown in Fig. 11.6. The individual contacts may be adjustable by screw

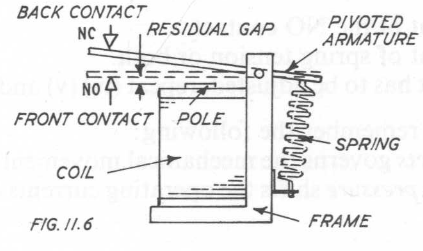


FIG. 11.6

(the actual contacts often being the tips of the screws, suitably plated with contact material); or be riveted to arms. In the latter case adjustment is made by bending the arms carefully.

The *pull in* current is governed by adjustment of the NC contact, and the spring tension. Bringing the armature closer to the coil polepiece will lower the pull-in current, and this movement will be opposed by spring tension.

The *drop out* current, and thus the differential, is primarily governed by the NO contact. The farther this holds the armature away from the coil polepiece in the pulled-in position, the higher the drop out current will be. Spring tension also affects drop out – the higher the spring tension the higher the drop out current.

The *residual gap,* when the armature is pulled in, is also an important factor, and one of the main adjustments which governs the spring tension required. If too small, the drop out will become sluggish and delayed. The armature must never actually touch the polepiece when pulled in, otherwise the drop out action will become extremely sluggish. A clearance of the thickness of a piece of stiff paper is usually about right.

Simplified relay adjustment can then be tackled on the following lines:

(i) Set the residual gap to the recommended clearance (above) by adjusting the NO contact and applying finger pressure to the armature.

(ii) Using a milliammeter and potentiometer temporarily connected in the receiver circuit, as shown in Fig. 11.5. Set the potentiometer for zero resistance (or short it out) and measure the receiver idling current and top current (i.e. responding to transmitter signal). This will establish the operating current range of the receiver.

(iii) Consult Table XV for recommended relay settings.

(iv) Adjust the pull in current to the recommended value, using the potentiometer to vary the current flowing through the relay by suitable adjustment of the NO contact in or out. If a suitable setting cannot be obtained by adjustment of the NC contact alone, alter spring pressure by bending the tab holding the bottom end of the spring.

(v) Check the residual gap again with the armature pulled in under current. If the armature is flexible (as it is on some relays), this may be less than originally set up. Re-adjust residual gap, if necessary, by the NO contact.

(vi) Find the *drop out* current by adjusting the potentiometer. If this does not give the recommended differential, then drop out will have to be adjusted by:

(a) adjustment of the NO contact
(b) adjustment of spring tension or both.

(vii) If the drop out has to be adjusted, repeat (iv) (v) and (vi) again.

As a general guide, remember the following:
Adjustment of contacts governs the mechanical movement of the armature.
Adjustment of spring pressure shifts the operating currents of the relay up or down.

Bonding

The subject of interference and suppression of electric motors and contacts has already been covered – see Chapter 6. Electrical 'noise' which can cause interference can also be generated by rubbing contact between metals, and may need additional treatment.

A typical example is the sliding contact between an escapement crank and a wire yoke – Fig. 11.7. This sliding metal-to-metal contact can generate interference, particularly as an escapement is usually mounted close to the receiver. Other possible causes of noise are wire fittings running in metal bushings, metal end linkages in contact with metal pins, etc.

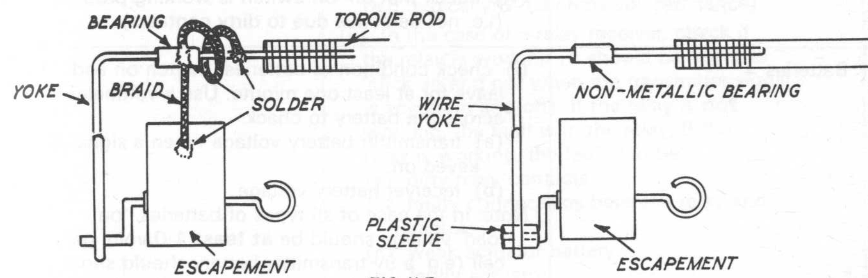


FIG. 11.7

The best way of eliminating potential sources of 'noise' is to avoid metal-to-metal contacts in all linkage movements, etc., particularly those close to the receiver. This can be done by selecting a plastic fitting to mate with a metal pin; or in the case of a wire yoke, insulating the wire by sleeving it with plastic tubing.

The alternative approach, where it is inconvenient or not possible to eliminate metal-to-metal contact is to *bond* the potentially troublesome components. Bonding consists of soldering a length of very flexible copper braid to connect the two sliding or rubbing metal components electrically, thus ensuring that both must always be at the same electrical potential and thus self-cancelling as regards 'noise'. The same principle of bonding can be applied to other types of metal-to-metal moving contacts, if necessary, leaving sufficient slack in the braid to accommodate the movement involved.

Table XIII Trouble shooting (Receivers)
Receiver does not respond to transmitter when both switched on and transmitter keyed 'on'.

Possible cause	*Action*
Connection fault	(i) check that wiring of receiver hook-up agrees with instructions. (ii) check for broken wires. (iii) check for faulty solder connections. (iv) check for faulty or dirty plug and socket connections. (v) check battery connections (especially dirty contacts or lack of spring pressure in battery boxes). (vi) check that on–off switch is working properly (i.e. not defective due to dirty contacts).
Batteries	(i) check condition of batteries. Switch on and leave for at least one minute. Use a voltmeter across the battery to check: (a) transmitter battery voltage when a signal is keyed on. (b) receiver battery voltage. Note: in the case of all types of batteries, 'on load' voltage should be **at least** 1·0 volts per cell (e.g. a 9v transmitter battery should show **at least** 6·0 volts; and a 3 volt receiver battery **at least** 2·0 volts). Replace dry batteries (or recharge nickel-cadmium batteries) as necessary. (ii) check that battery polarity is correct (e.g. particularly make sure that batteries are fitted in a battery box the right way round).
Receiver not tuned to transmitter	Adjust tuning control of receiver with transmitter signal held on until a response is obtained. Then tune to optimum setting of tuning plug. Note: this applies only in the case of superregen receivers.
Transmitter fault	(i) Transmitter battery too weak. (ii) transmitter aerial not fitted properly, or poor connection. (iii) damage to transmitter components – e.g. tuned circuit coil.* (iv) faulty components.* * Return to manufacturer or service agent for checking and repair, if necessary.
Receiver fault	(i) Receiver battery too weak. (ii) receiver aerial wire accidentally 'earthed' – e.g. touching damp ground. (iii) Damage to receiver components.* (iv) Faulty receiver components.* * Return to manufacturer or service agent for checking and repair, if necessary.

Table XIII Trouble shooting (Receivers) – Continued

Possible cause	*Action*
Relay (Relay receivers only)	(i) Faulty relay adjustments.* (ii) Dirty relay contacts.* (iii) Relay damaged by shock (e.g. after a crash).† * See section on 'Relay Adjustment'. † Return to manufacturer or service agent for checking and re-adjustment or replacement as necessary.
Faulty Actuator	(i) In the case of relayless receivers, check that the actuator is a suitable matching type (e.g. typically 8–10 ohms coil resistance). (ii) In the case of a relay receiver, check if the relay is working (it should be heard to 'click' in and out when the transmitter signal is keyed on and off). If the relay is **not** working, the fault is in the relay. If the relay is working, the fault can be: (a) dirty relay contacts. (b) faulty connections between relay and actuator. (c) weak actuator battery. (d) faulty actuator. Note: if a spare single-channel actuator is available, use this to replace the original actuator. If the second actuator works, the first actuator is faulty. If new, return to manufacturer or supplier for replacement under guarantee. If an old actuator, discard and replace with a new one.

Table XIV Trouble shooting – complete sets
Equipment operates or responds, but not in correct manner.

Behaviour	*Cause and/or Action*
Relay clatters (Relay receivers; or relayless receiver connected to a relay)	(i) May be due to receiver being slightly off tune – re-tune to optimum position. (ii) Faulty relay adjustment – re-adjust (iii) Transmitter circuit fault – check. (iv) Receiver circuit fault – check. (v) Weak batteries – check. (vi) Interference from self-generated 'noise'. See section on 'Bonding'. (vii) External interference by spurious signals. Note: there is a distinction between a relay which clatters on a static test, and one which clatters with the engine running. If clatter only occurs in the latter case suspect engine vibration or 'noise'.

Table XIV Trouble shooting – complete sets – Continued

Behaviour	*Cause and/or Action*
Engine vibration (i/c engines)	(i) Reduce vibration in the case of an aircraft engine by balancing the propeller (or try fitting the propeller at a different position on the crank shaft. (ii) Improve vibration isolation of receiver (e.g. – with more foam-rubber packing. Locate receiver further away from engine, if practical.
Engine 'noise' (electric motors)	(i) Apply suppression to electric drive motor (see Chapter 6). (ii) Locate receiver as far away from electric drive as possible.
Escapement 'clatters'	(i) Causes and treatments as for relay clatter above, but most likely to be due to: (a) engine vibration – reduce with a properly balanced propeller. (b) self-generated noise – which can be cured by bonding. (c) weak actuator battery – check.
Motorised Actuator sticks or is sluggish	(i) Dirty switching contacts – disassemble actuator carefully and clean contact surfaces and brushes. (ii) Binding reduction gearing.
Lack of range	(i) Weak batteries (check transmitter and receiver batteries 'on load'). (ii) Marginal tuning – check and re-adjust receiver tuning to optimum setting. (iii) Inefficient transmitter aerial – e.g. not extended, or poor connection at base. (iv) Moisture on base of aerial. (v) Inefficient receiver aerial – e.g. wire broken off inside set, cut too short, or touching an 'earthed' surface. (vi) Unfavourable operating conditions – e.g. presence of overhead power lines or transmitter resting on damp ground.
Escapement 'unwinds' as soon as rubber motor is wound up	Rubber motor wound in wrong direction.
Escapement 'skips' with wound rubber motor	(i) Escapement motor too powerful – use smaller width rubber. (ii) Poor adjustment of escapement movement. (iii) Interference.

Table XIV Trouble shooting – complete sets – Continued

Behaviour	*Cause and/or Action*
Escapement 'sticks' with wound rubber motor	(i) Escapement motor too powerful – reduce number of turns or use smaller width rubber. (ii) Excessive friction on connecting linkage. (iii) Escapement motor too weak, or unwound. (iv) Burrs on escapement movement. (v) Bent or damaged escapement movement. (vi) Stiff hinges on control surface.
Control surface sticks 'on'	As for escapement 'sticks' above.
Control surface sticks 'off'	(i) Escapement motor unwound. (ii) Escapement motor too weak. (iii) Excessive friction in linkage. (iv) Weak actuator battery. (v) Excessive load on control surface.
Secondary Actuator does not operate	(i) Faulty connections or wiring. (ii) Dirty switching contacts on main actuator. (iii) Weak actuator battery. (iv) Faulty adjustment of switching contacts.
Main and secondary controls interact	(i) Electrical interference – suppression or bonding may be required. (ii) Weak actuator battery.

Table XV Relay current values
(all currents in milliamps)

Maximum receiver current	*Pull-in*	*Drop-out*	*Differential*
2	1·5	1·3–1·2	0·2–0·3
5	3	2·8–2·7	0·2–0·3
10	6	5	1
20	12	10	2
50	30	25	5
100	60	50	10

CHAPTER TWELVE

WORKSHOP TIPS

The widespread adoption by equipment manufacturers of pre-soldering receiver and actuator wiring to plugs and sockets, and supplying 'complete' wiring harnesses has probably done as much as anything else to improve radio control reliability. In the past, where everyone had to wire up and solder their own installation connections, more than 80 per cent of all operating faults could be traced to poor soldered joints!

However, the ability to handle a soldering iron properly is still important. Certain wiring connections may still have to be added in a complete installation, and a pre-wired plug or socket can have a wire break off, calling for re-soldering.

Only an *electric iron* should be used for such work. One with a 10 watt rating and a $\frac{1}{16}''$ or $\frac{3}{32}''$ bit is suitable for small work – soldering individual connections, or working in small spaces. A larger iron with a rating up to 25 watts and a $\frac{1}{8}''$ bit is more suitable for general soldering work, or where a large number of connections have to be soldered at one time.

Only a mains (250 volt) iron should be used for normal work. A battery powered iron can be used for field repairs, but should not be regarded as a suitable workshop tool.

Only *resin cored solder* should be used for electrical work. This is sold in 'wire' form, $\frac{1}{16}''$ diameter being the most suitable for general work. No. 2 size can be used for soldering on printed circuit or in tight spaces where it is necessary to avoid getting too much molten solder on the job. The best *grade* of solder for electrical work is 60:40 alloy. Other alloys have a higher melting point, making it more difficult to produce good joints quickly.

The basic rules for good soldering are then:

(i) Make sure that the surfaces to be joined are *quite clean*. If necessary, clean with fine emery cloth or by scraping with a modelling knife – and avoid 'fingerprinting' the surfaces after cleaning.

(ii) The tip of the iron must also be clean. When hot, the tip should be coated with a clean silvery film of molten solder.

(iii) Allow adequate time for the iron to heat up before trying to complete a soldered joint.

(iv) Apply the tip of the hot iron to the joint first, then press solder onto the heated area. It should melt and flow smoothly over the joint area. Avoid

using too much solder, but always make sure that enough solder is applied 'flood' the joint properly.

The checks on a good soldered joint are:

(i) The solder should have a bright, smooth appearance when solidifi and cover the whole joint area. If the solder is 'white' and rough or crystalli in appearance, then the joint is poor. This is probably due to the iron n being hot enough. A small iron used on a large area will also produce t effect. Too much heat is conducted away from the tip of the iron to allow it heat up to the proper bit temperature.

(ii) The solder is evenly spread over the joint. If not, then the jo surfaces were not clean enough.

(iii) A soldered joint should be completed in not more than 3 or 4 secon If it takes longer, then either the iron is not hot enough, or the joint surfa are not clean.

As an invariable rule, *all wiring should terminate in soldered joints*. Ne twist wires together to make a connection, or use 'mechanical' connectio (e.g. wires joined by screw connectors, or terminated under the heads screws). The only form of 'mechanical' connectors acceptable are h quality plugs and sockets. These provide *good* connections because of th tight, sliding fit – provided the wires connecting to the plug and sockets soldered in place.

Wiring

Stranded rather than 'solid' wire should always be used for general wiri Small diameter stranded wire is designated by two numbers, separated by The first number refers to the number of strands, and the second to the w diameter size, either in inches or standard wire gauge, e.g.

12/004 wire designates 12 strands of ·004 ins. diameter wire.

12/42 wire designates 12 strands of 42 swg wire (these two examples identical since 42 swg is equivalent to a wire diameter of ·004 ins.).

Recommended sizes of wire are:

12/004 (12/42) for general receiver circuit wiring (but not for escapem circuits).

14/0076 (14/36) for escapement circuits, or other circuits where volt drop through wire resistance is to be minimised.

Stranded wire is produced in insulated form (covered with plastic), w different coloured coverings. Logically different coloured wires should used for different parts of the circuit, for ease of identification if a check to be made on connections. However there is no universal colour code wh applies. Individual manufacturers often adopt their own idea of col coding, and some are not even consistent in this with different types equipment. Table XVI lists *suggested* colour coding, but is only advan as a recommendation for 'freelance' wiring. It is not necessarily applicabl *any* pre-wired circuit.

For neatness, and also to prevent wiring moving about, bundles or gro

of individual wires running together should be cabled up, and supported in some way. A simple method of 'cabling' using thin string is shown in Fig. 12.1. Cable runs can be fixed to a suitable surface, e.g. the side of a fuselage, with strips of servo tape; or simply packed in place with the foam rubber used to cushion the receiver, etc.

The importance of leaving 'slack' at the ends of cabling runs where the wires join a component have already been emphasised in Chapter 4. Fig. 12.2 elaborates on this theme, showing recommended methods of binding wires, etc., to the components they feed with a permanent, and fixed, loop of slack. This will obviate any chance of a wire being pulled taut to put strain on the soldered connection. Taut wires can readily break at the joint under the influence of sustained vibration – or the jerk caused by the impact of a crash landing.

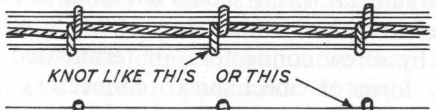


FIG.12.1

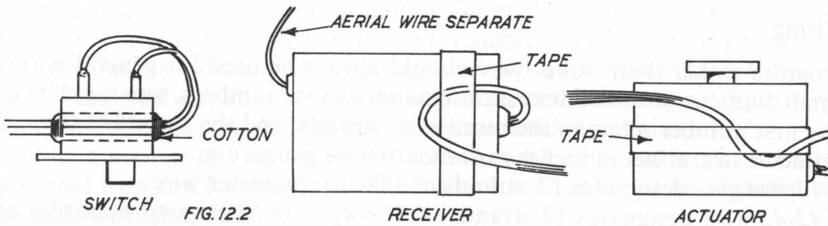


FIG.12.2

Making up battery packs

Where dry cells are used for receiver/actuator batteries these can be made up in 'packs' of the appropriate voltage by taping the required number of cells together and completing the connections with soldered leads – Fig. 12.3. External connections should terminate in a *socket* to connect to the installation wiring via a matching plug on the permanent wiring.

A made-up battery pack saves the cost, space and weight of a battery box, and also eliminates the possibility of poor connection between cell and battery box terminals. It does mean extra work in making up packs, which are discarded after a relatively short period of use. The socket can, of course, be unsoldered from a used pack and used with further packs.

Connecting wires are easily soldered to standard dry cells, provided the end cap and base (especially) are mechanically cleaned, i.e. by rubbing with emery. Soldered connections are much more difficult to make on the base of

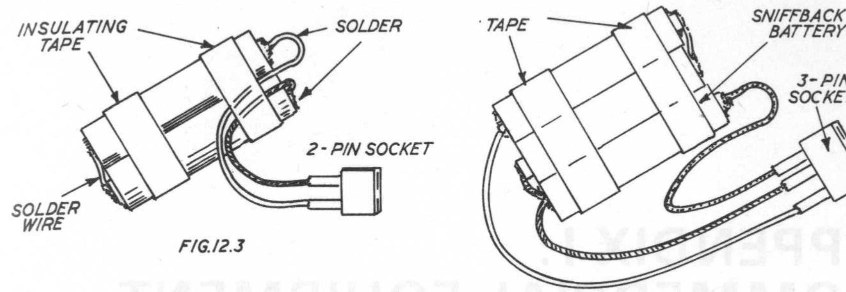


FIG.12.3

leakproof cells (which include alkaline-manganese types), because of t different material used for case construction. Some people find it virtua impossible to make suitable soldered connections with these types, usi resin cored solder. This can be the one exception to the general rule where acid-type soldering flux can be used – e.g. Baker's fluid – provided the jo is thoroughly neutralised by painting with a strong soda solution after t joint has been made and cooled down.

Instruments

Even when single-channel radio equipment is regarded as 'black box which work (or do not work, as the case may be!), it is useful to have sor means of simply checking circuits. A *multimeter* is recommended as this c perform the role of:

(i) Voltmeter to check battery voltages. Remember that battery voltag should be checked with the circuit switched on and under load to give a tr indication of the state of the battery.

(ii) A *milliammeter* for checking current drawn by a circuit (interpo the meter in one battery lead); and also for adjusting relays, if necessary.

(iii) An *ohmmeter* for checking the continuity of a circuit.

Table XVI Wiring colour codes (suggested usage)

Colour	Duty
Red	battery positive
Black	battery negative; common connection
Yellow	actuator lead
Orange	actuator lead
Brown	relay NC (back contact); actuator lead
Blue	relay NO (front contact); actuator lead
Green	relay armature; actuator battery +
White	aerial wire; earphone connection

APPENDIX I: COMMERCIAL EQUIPMENT

This summary lists only commercial single-channel radio equipment available readily in this country (1973) from major suppliers. Manufacture of single-channel equipment has virtually ceased in Continental Europe, but other equipment is also produced in the United States and Japan.

In addition to the major British manufacturers (and distributors) listed, a number of firms specialise in the supply of kits for home construction of single-channel transmitters and receivers. For current information on this subject, consult the advertisements in the monthly radio control model journals, e.g. RADIO CONTROL MODELS AND ELECTRONICS (published on the second Friday of each month by Model and Allied Publications.)

Single-channel transmitters

Manufacturer (U.K. distributor)	*Type(s)*	*Remarks*	*Pri (19*
A.B.C.† (Keilkraft)	Mini Sonic	crystal controlled	ø (£6·
MacGregor* (Ripmax)	Powermac	crystal controlled	£10
	Codamac	crystal controlled, 'stick' control and 'quick-blip' button	£15
	Galloping Ghost	variable mark-space and variable pulse rate from joystick control; plus 'quick-blip' button	£19
O.S.‡ (Keilkraft)	Pixie	crystal controlled	£8
Radio Control† Specialists	Guidance system	crystal controlled	£7
Ripmax-Futaba ‡ (Ripmax)	F21 Pocket TX	miniature, crystal controlled	
	F22 Power Plus	crystal controlled	
	F23 Codemaster	joystick gives sequence signals; plus separate 'quick-blip' key	
Ripmax-Pathfinder † (Ripmax)	Pathfinder	crystal controlled	

* Only sold with matching receiver as a 'combo'. ø discontinued 1
† British manufacturer.
‡ Japanese manufacturer.

Single-channel receivers

Manufacturer (U.K. distributor)	*Name*	*Type*	*Remarks*	*Price (1973)*
A.B.C.† (Keilkraft)	Minisonic	superregen	relayless	ø (£4·92)
			relay	ø (£6·33)
MacGregor † (Ripmax)	Minimac	superregen	relayless	£5·25
			relay	£6·95
	Supermac	superhet	relayless	£7·25
			relay	£8·95
O.S.‡ (Keilkraft)	Pixie	superregen	relay	£5·22
Radio Control † Specialists	Guidance System	superregen	relayless	£5·50
	Guidance System	superhet	relayless	£7·50
			relay	£9·50
Ripmax-Futuba ‡ (Ripmax)	FR31 Microgen	superregen	relayless	£5·20
	FR32 Microgen	superregen	relay	ø (£6·20)
	FR33 Microhet	superhet	relay	ø (£11·30)
Ripmax-Pathfinder † (Ripmax)	Pathfinder	superregen	relayless	*

* Sold only as a 'combo'. ø discontinued 1972
† British manufacturer.
‡ Japanese manufacturer.

Single-channel escapements

Manufacturer (U.K. distributor)	*Name*	*Type*	*Remarks*	*Price (1973*
Elmic* (Keilkraft)	Conquest	2P S/N	simple rudder escapement	£1·9
	Commander	2P S/N	selective, with built-in switching contacts	£2·9
	Compact	3P S/N compound	also incl. switch contacts	£3·4
	Corporal	progressive	motor control escapement	£2·9
Fred Rising* (Keilkraft)	Lightweight	2P S/N	simple rudder escapement	£1·1
	Compound	2P S/N	selective, compound	£2·3
	4-pawl	4P progressive	clockwork driven	£2·0
	2-pawl	2P S/N	clockwork driven	£1·9
Ripmax-Futaba † (Ripmax)	FR61 Rudamite	3P S/N	selective action	£1·9

Single-channel motorised actuators

Manufacturer (U.K. distributor)	*Name*	*Type*	*Price (1973*
Ripmax-Orient† (Ripmax)	Minimite	rudder servo (compound)	£3·2
	Minimo	motor servo	£3·2
MK† (Ripmax)	Dynamo	Special motor servo	£4·4
	Dynavator	special elevator servo	£4·9

* British manufacturer.
† Japanese manufacturer.

American single-channel escapements

Most of the escapements listed here are obsolete, although examples may still be obtainable from individual sources. They are included mainly for reference purposes, as American escapements largely set world design standards for mode of working and accuracy of construction.

Name	*Size (ins.)*	*Weight (ozs.)*	*Action*	*Application*
Babcock				
Mk. II	$1\frac{3}{8} \times 2\frac{1}{2} \times 1$	$\frac{3}{4}$	3 selective positions, self-neutralising	Rudder and extra service †
Motor* Compound	$1\frac{3}{4} \times 1 \times 4\frac{1}{2}$	1	2 position 3 selective positions, self-neutralising	Motor speed Rudder and elevator
Bonner				
Varicomp	$2\frac{1}{8} \times 1\frac{1}{4} \times 1\frac{1}{4}$	$1\frac{1}{4}$	3 selective positions, self-neutralising	Rudder and extra service †
SN	$1\frac{1}{2} \times 1\frac{1}{2} \times 1\frac{1}{4}$	$\frac{5}{8}$	2 position, self-neutralising	Rudder
Cameron				
Compound	$1\frac{5}{8} \times 3 \times 1\frac{1}{8}$	$1\frac{1}{4}$	3 selective positions, self-neutralising	Rudder and extra service †
2-POSN	$1\frac{5}{8} \times 3 \times 1\frac{1}{8}$	1	2 position, self-neutralising	Rudder
4-POSN	$1\frac{5}{8} \times 3 \times 1\frac{1}{8}$	1	4 position	Motor speed or trim
Citizenship				
SE	$1\frac{3}{8} \times 1\frac{3}{8} \times \frac{5}{8}$	$\frac{3}{4}$	2 selective positions, self-neutralising	Rudder
PSN	$\frac{7}{8} \times \frac{7}{8} \times \frac{5}{8}$	$\frac{5}{8}$	2 position, self-neutralising	Rudder
Cob				
SN2	$1\frac{3}{8} \times 2 \times \frac{5}{8}$	$\frac{3}{4}$	2 position, self-neutralising	Rudder
3 POSN	$1\frac{3}{8} \times 2 \times \frac{5}{8}$	$\frac{3}{4}$	3 position	Motor speed or trim
Rand				
LR3			galloping ghost	Rudder/elevator throttle †
Adams			magnetic	Pulse

* Air-bleed action.
† Via secondary escapement.

Single-channel motorised actuators

Manufacturer (U.K. distributor)	*Name*	*Type and remarks*	*Pri (197*
Climax* (Keilkraft)	Unimite	2P S/N can also be supplied with progressive action for throttle control	£3·
O.S.† (Keilkraft)	S-103	2P S/N main actuator with switching facility	£4·
	S-104 M	3P progressive	£4·
Ripmax-Orient † (Ripmax)	Minimite	2P S/N main actuator with switching facility	£2·
	Minimo	3P progressive for throttle	£2·
Ripmax-MK † (Ripmax)	Dynamite (S)	3P S/N main actuator with two switching facilities	£4·
	Dynamo (S)	throttle actuator	£3·
	Dynavator (S)	elevator (or aileron) actuator	£4·
Ripmax-Futaba † (Ripmax)	Ergamite Special	3P S/N main actuator	£4·
	Ergamo	2 or 3P progressive actuator for throttle control	£3·
MacGregor*	Under development for production in 1973		

* British manufacturer.
† Japanese manufacturer.

APPENDIX II: BRITISH EQUIPMENT SPECIFICATIONS

Specifications: MacGregor single-channel transmitter and receivers

Transmitter

Size	$6'' \times 3\frac{3}{8}'' \times 1\frac{1}{4}''$
Weight	$6\frac{1}{2}$ ozs.
Supply voltage	9 volts
Current consumption	Approximately 50mA
Modulation	Clipped sine wave at 1,000 c/s
Frequency	27·255 Mc/s

Minimac Receiver

Case size Relay	$2\frac{1}{4}'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$
Relayless	$1\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$
Weight Relay	$1\frac{1}{2}$ ozs.
Relayless	1 oz.
Supply voltage	9 volts
Standby current	Approximately 3mA
Maximum output current (Relayless)	500 mA
Recommended Actuator Resistance	8 to 14 ohms

Superhet Receiver

Case size Relay	$2\frac{3}{4}'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$
Relayless	$2'' \times 1\frac{1}{2}'' \times \frac{7}{8}''$
Weight Relay	$2\frac{1}{4}$ ozs.
Relayless	$1\frac{1}{2}$ ozs.
Supply voltage	9 volts
Standby current	Approximately 4 mA
Maximum output current (Relayless)	500 mA
Recommended Actuator Resistance	8 to 14 ohms
I.F. Frequency	470 Kc/s
Selectivity	22 db down at ± 9 Kc/s from centre frequency

Specification: MacGregor 'Digimac' 1 +1

Transmitter

Size: 151 mm × 89 mm × 38 mm (6″ × 3·5″ × 1·5″)
Weight: 12·75 ounces with dry cells
Aerial: Bottom loaded; 1·26 m (48″) fully extended; 61 mm (2·4″) retracted
Supply: 9–10 volts Dry Cells or Ni/Cads

Receiver

Size: 70 mm × 38 mm × 22 mm (2·75″ × 1·5″ × 0·875″)
Weight: 2·25 ounces (64 gms)
Supply: 6 volt Dry Cells or 4·8 volts Ni/Cad
I.F. Frequ.: 470 KHz.

Servos

Size: 48 mm × 36 mm × 21·5 mm (1·875″ × 1·4″ × 0·85″). Output arms extend 6·5 mm (0·25″) above case. Lugs extend 8 mm (0·3″) each side
Weight: MR10 – 1·8 ounces (51 gms)
MR9 – 1·7 ounces (48·2 gms)
Output: MR10 – Rotary up to 5 lbs (2·3 Kgm) over 90 deg. transit
MR9 – Linear 3 position. Pull 5 lbs (2·3 Kgm)
MR10 Transit Time – 1·0 sec. for full travel
Supply: 2·4 + 2·4 volts

Battery Pack (AP09)

Size: 60 mm × 30 mm × 30 mm (2·375″ × 1·16″ × 1·16″)
Weight: 2·8 ounces (79·5 gms) with switch, harness and 4 × $1\frac{1}{2}$ volt pencells

All Up Weight

Including Rx, AP09 Battery Pack and 2 servos – 8·55 ounces (243 gms)

Specification: RCS Guidance System transmitter

Five-transistor unit operating on 9 to 12 volts supply crystal controlled.

Current consumption:	25 to 30 mA, aerial extended
R.F. output:	Not less than 250 mW
Recommended batteries:	Two 6 volt PP.1 or equivalent
Size:	$5\frac{1}{2}'' \times 3\frac{1}{2}'' \times 2\frac{3}{8}''$
Weight:	less batteries – $1\frac{1}{2}$ lb

Superregen Receiver

Five-transistor unit operating on 3·6 to 4·5 volts.

Output current:	400 mA on 4·5 v
Minimum output load:	9 ohms
Recommended output load:	11 ohms e.g. Elmic escapements
Size:	$1\frac{13}{16}'' \times 1\frac{5}{16}'' \times 1''$ (MK. II) $1\frac{13}{16}'' \times 1\frac{5}{16}'' \times \frac{7}{8}''$ (MK. III)
Weight:	$1\frac{1}{2}$ oz
Recommended batteries:	3·6 volt Deac cells or 4·5 volts U7 pencel similar Long Life types

Superhet Receivers

The single-channel superhet version is available either with a transistor output switc escapements, or with a Kaco relay for use with certain types of motorised actuator. Opera voltage is 4·8 or 6·0 respectively, and this must be supplied by a Deac battery (225 m capacity recommended).

Operating voltage:	4·8 or 6·0
Current:	Carrier only – 4 mA
Current:	Typical (tone modulation) 400 mA (Escapement) or 140 mA (relay)
Intermediate frequency:	470 Kc/s
Size:	$3\frac{1}{16}'' \times 2\frac{1}{8}'' \times 1\frac{1}{8}''$
Weight:	4 ozs approximately

APPENDIX III: WIRING DIAGRAMS, ETC. FOR COMMERCIAL SINGLE-CHANNEL EQUIPMENT

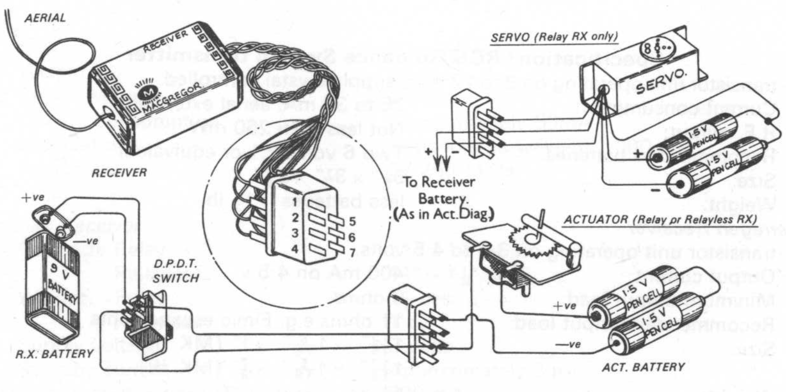


Fig. 13.1 Macgregor single-channel receiver

7 PIN PLUG CONNECTIONS

Relay Receiver Pin	Wire colour	Designation	Relayless Receiver Pin	Wire colour	Designation
1		Not Used	1	Violet	For add on relay pack
2	Red	Rx battery +ve	2	Red	Rx battery +ve
3	Black	Rx battery —ve	3	Black	Rx battery —ve
4		Not Used	4		Not Used
5	Green	Common or armature	5	Green	Actuator battery —ve
6	Brown	Normally closed	6		Not Used
7	Blue	Normally open	7	Blue	Rx output

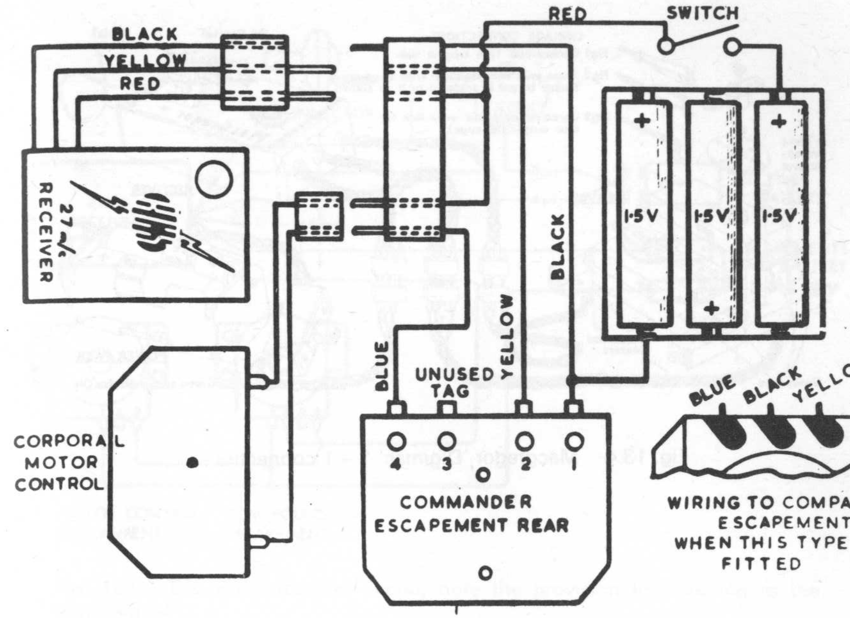


Fig. 13.2 'RCS' single-channel relayless receiver

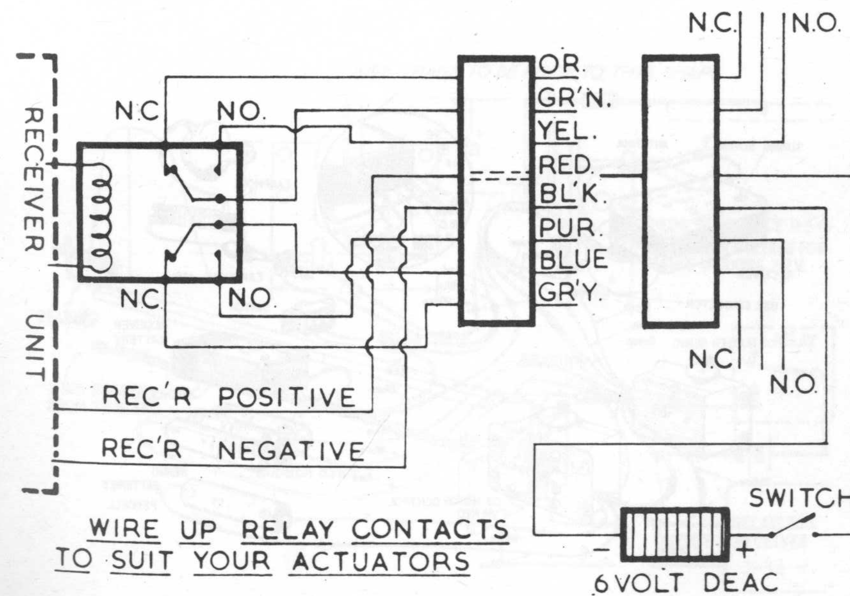


Fig. 13.3 'RCS' single-channel relay receiver

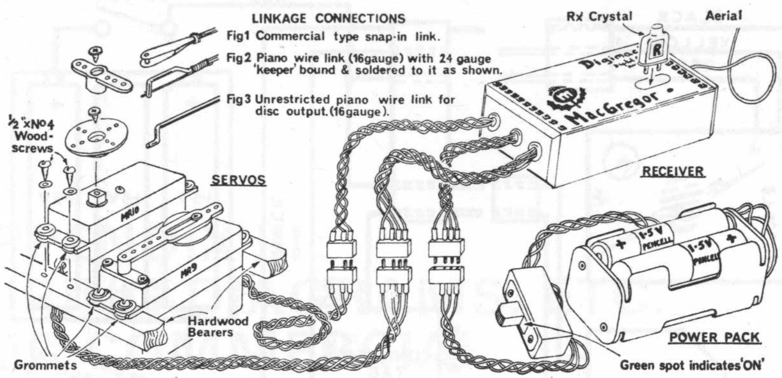


Fig. 13.4 Macgregor 'Digimac' 1 +1 connections

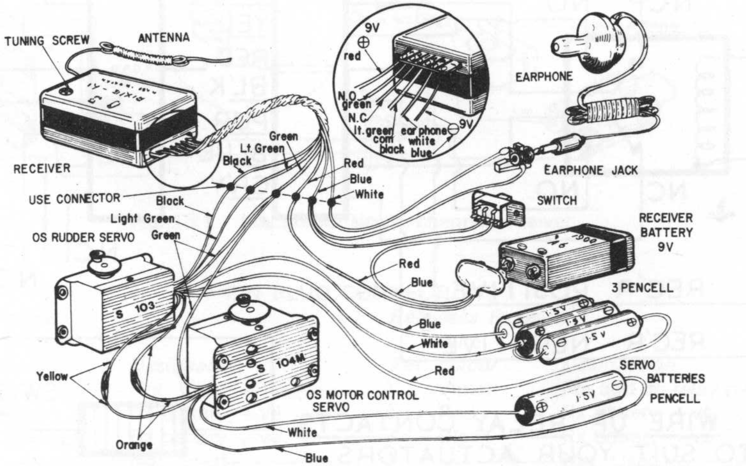


Fig. 13.5 O.S. Pixie Single-Channel System (Keilcraft)

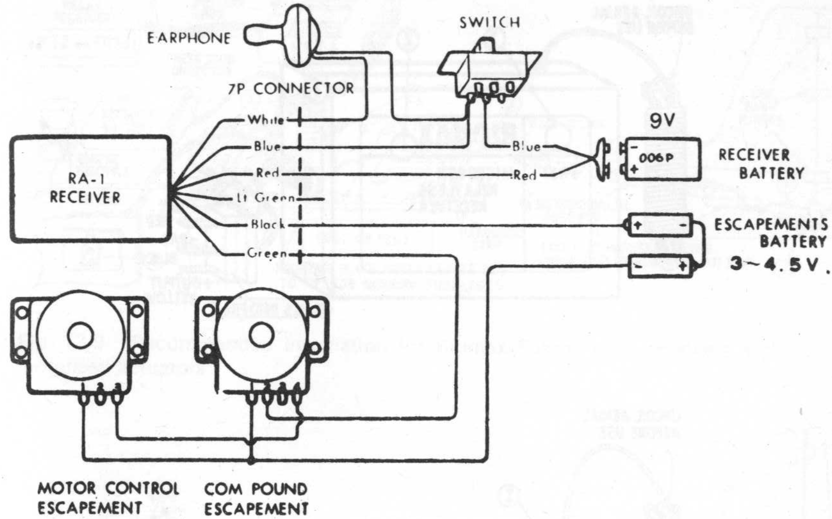


Fig. 13.6 OS 'Pixie' receiver circuit, note the provision for listening to the 'tone' signal

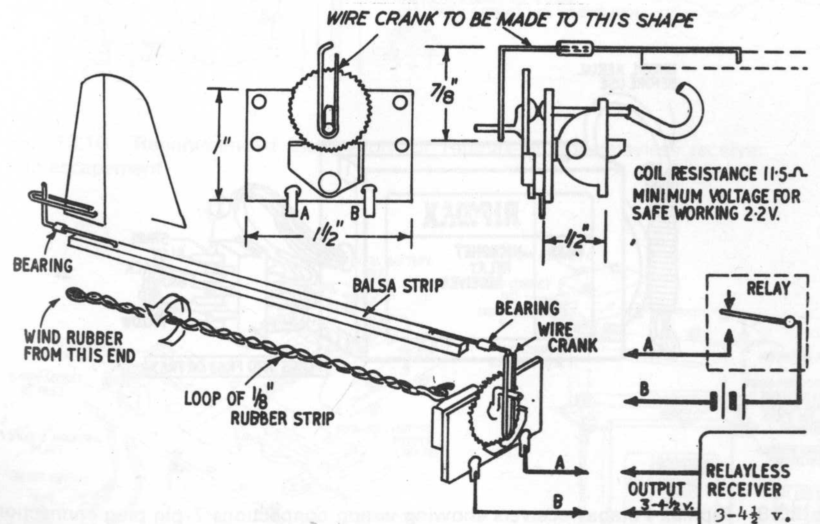


Fig. 13.7 Ripmax 'Pathfinder' escapement installation and wiring connections

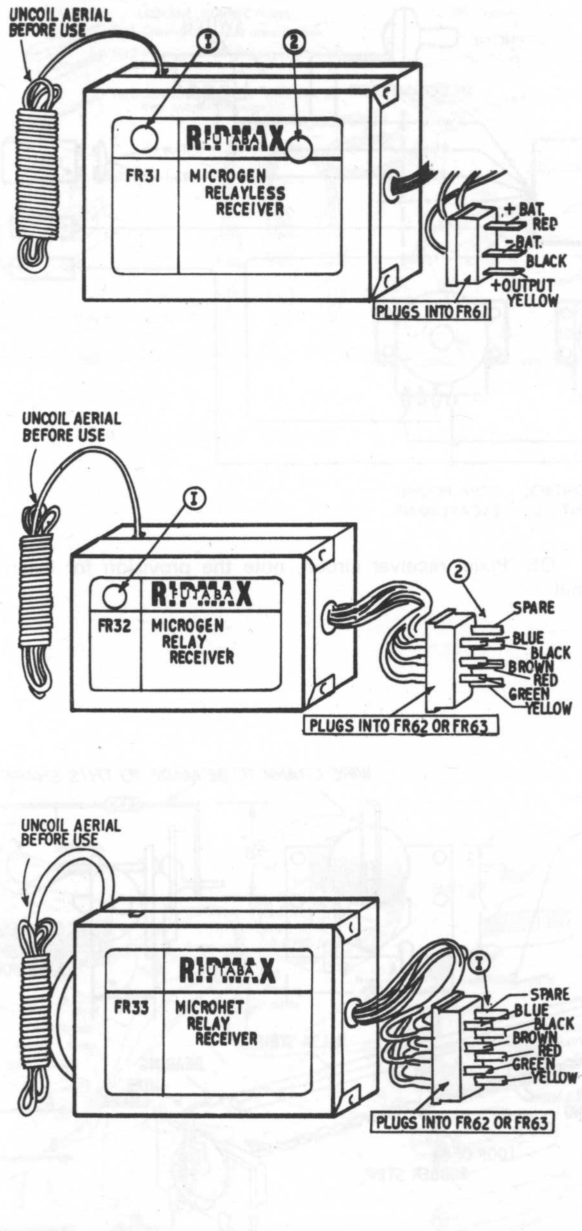


Fig. 13.8 Ripmax-Futaba receivers showing wiring connections 7-pin plug connections (1) Black – receiver battery negative, Red – receiver battery positive, Yellow – earphone test point (-ve), Blue – relay 'Make' contact (N/O), Brown – relay 'Break' contact (N/C), Green – relay armature contact (C)

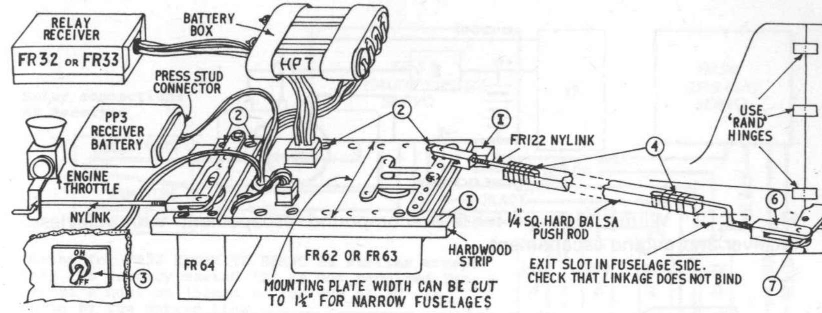


Fig. 13.9 Recommended installation for Ripmax-Futaba relay receivers and motorised actuators

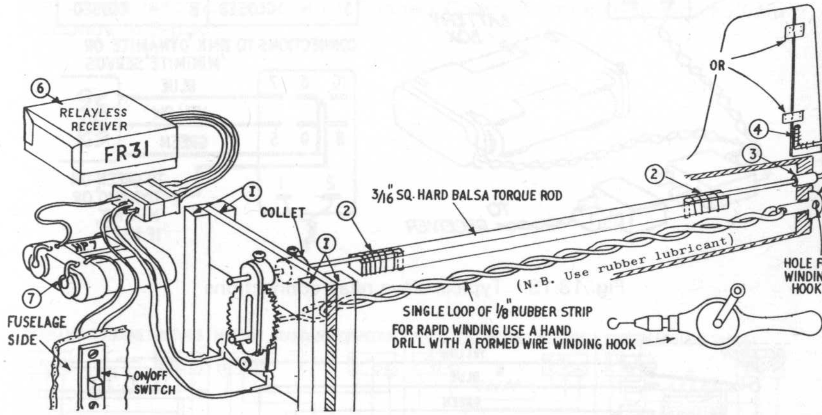


Fig. 13.10 Recommended installation for Ripmax-Futaba relayless receiver and escapement

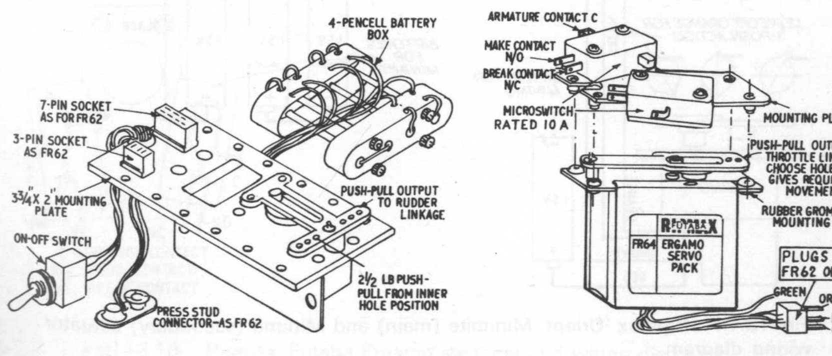


Fig. 13.11 Ripmax-Futaba Ergamite Special (main) and Ergamo (secondary) actuators, with switcher mounted on Ergamo.

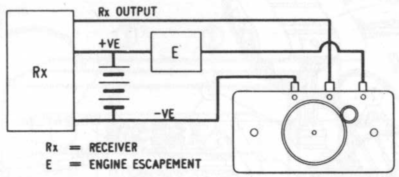


Fig. 13.12 Wiring diagram for F.R. compound escapement with relayless receiver and engine escapement

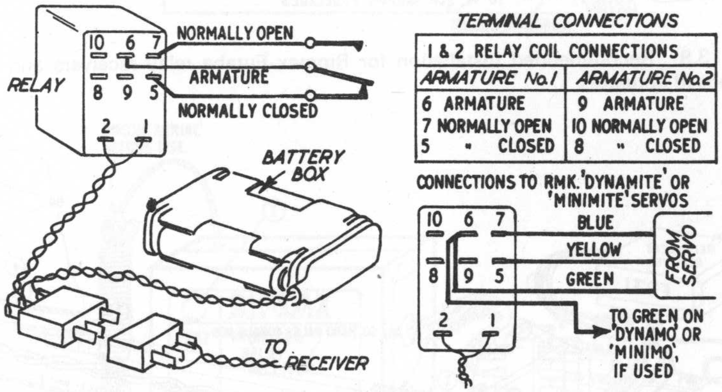


Fig. 13.13 Typical slave relay connections

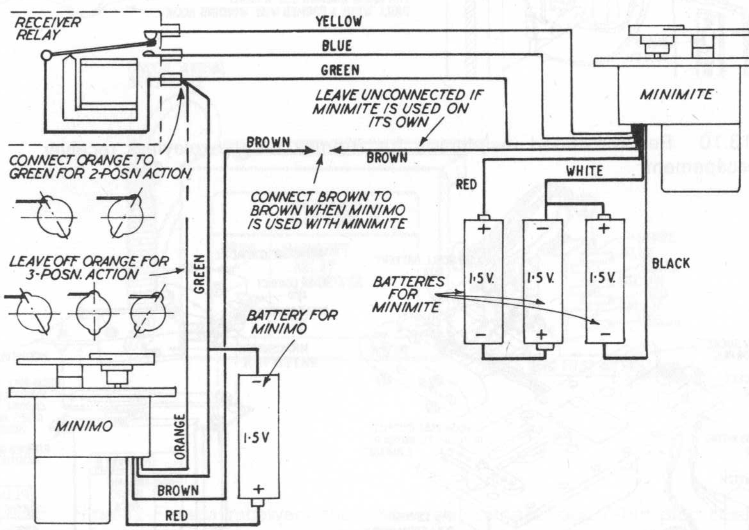


Fig. 13.14 Ripmax 'Orient' Minimite (main) and Minimo (secondary) actuator wiring diagram

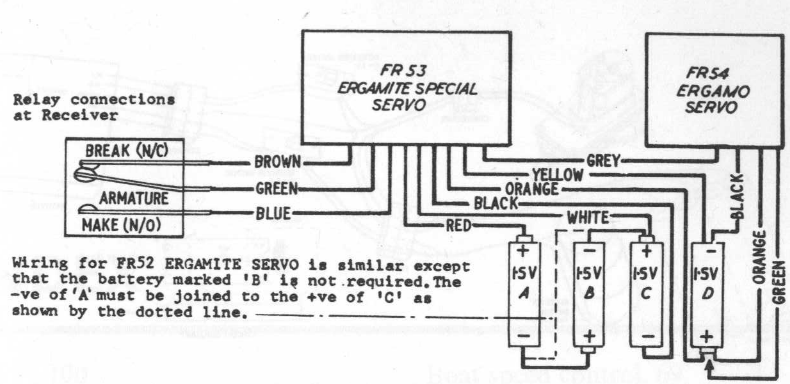


Fig. 13.15 Wiring diagram for Ripmax-Futaba Ergamite Special (main actuator) and Ergamo (secondary actuator). Connect Green wire to convert Ergamo from 3-position to 2-position

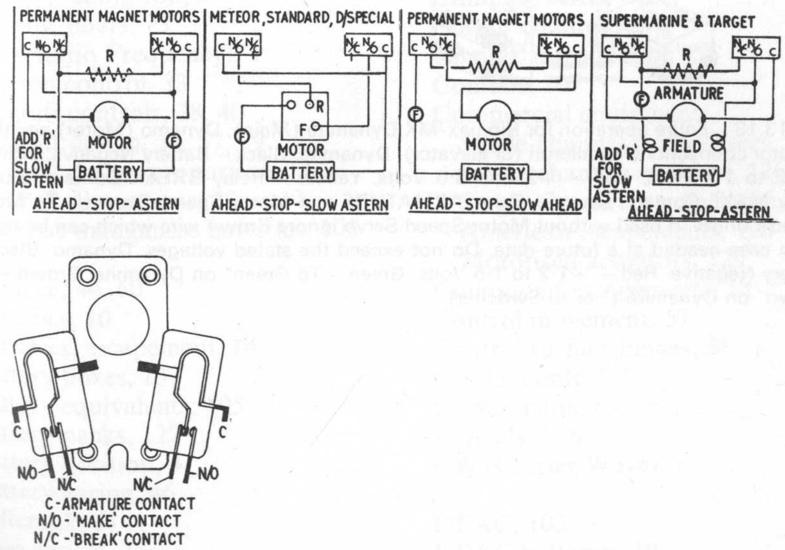


Fig. 13.16 Ripmax-Futaba Ergamo switcher and wiring diagrams

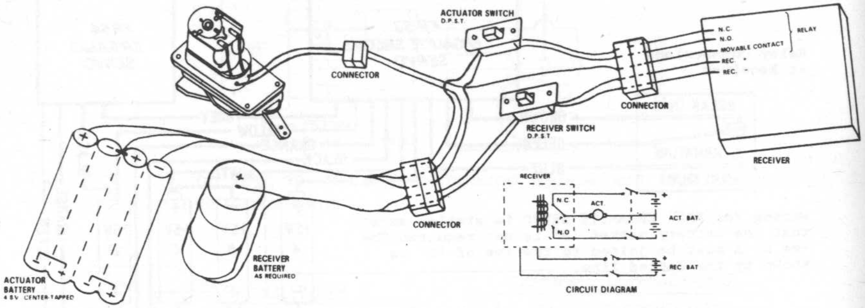


Fig. 13.17 Rand LR3 'Galloping Ghost' actuator wiring circuit

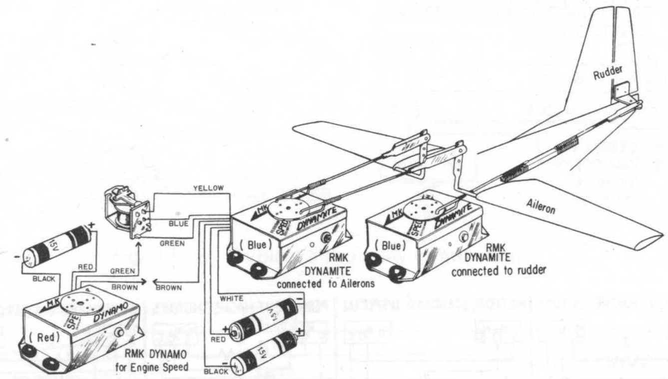


Fig. 13.18 Entire operation for Ripmax-MK Dynamite (Main), Dynamo (Motor) and third actuator connections for aileron (or elevator). Dynamite: Black – Battery Negative, White – +1·2 to 1·5 Volts, Red – +2·4 to 3·0 Volts, Yellow – Relay BREAK Contact, Blue – Relay MAKE Contact, Green – Relay ARMATURE and Motor Speed, Brown – To Motor Speed Control. If used without Motor Speed Servo ignore Brown wire which can be taped off in case needed at a future date. Do not exceed the stated voltages. Dynamo: Black – Battery Negative, Red – +1·2 to 1·5 Volts, Green – To Green* on Dynamite, Brown – To Brown* on Dynamite (* or to Switcher)

INDEX

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